

MANUAL
of
“Exide” Batteries
in
Electric Vehicles

Price, \$1.00

THE ELECTRIC STORAGE BATTERY CO.
PHILADELPHIA

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NOTE.—The sections are published separately and can be secured on application.

THE ELECTRIC STORAGE BATTERY CO.

PHILADELPHIA, PA.

MANUFACTURER OF

The "Exide," "Hycap=Exide," "Thin=Exide" and
"Ironclad=Exide" Batteries for Electric Vehicles

SALES OFFICES

PHILADELPHIA, Allegheny Ave. and 19th St.

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CANADA

The Canadian General Electric Co., Ltd.
King and Simcoe Sts., Toronto

Receiving a New Battery

In unpacking a battery, keep the trays right side up in order to avoid spilling the electrolyte (battery solution).

Unpacking

After cleaning off the excelsior, etc., from the tops and sides of the trays, remove all the soft rubber plugs from the cells and see if all cells contain the proper amount of electrolyte.

Inspecting
Individual
Cells

The electrolyte should be about one-half inch above the top of the plates.

If the electrolyte is uniformly below the proper level, add enough distilled or other pure water to bring the level to the proper height.

If the level of the electrolyte in some cells is found *below* the top of the plates, it is due to loss of electrolyte.

Electrolyte
Lost in
Shipment

If due to the tray having been turned over during shipment, the excelsior around the top of the tray will be wet, and some acid would be spilled from *all* of the cells in that tray. In this case, replace the amount spilled by filling the low cells to the proper height with chemically pure electrolyte of about 1.250 specific gravity (7 parts of pure water and 2 parts pure sulphuric acid by volume).

If the electrolyte in a cell is low, due to a broken jar, the bottom of the tray will be wet although the excelsior around the top of the tray may be dry. Replace the broken jar and add sufficient acid to make up for the amount lost.

If it is found, after replacing the broken jar and giving the battery an equalizing charge, that the gravity does not come to approximately 1.275, it is due to not having replaced the same amount of acid as was spilled. To adjust this, draw off some of the electrolyte from the top of the cell and add water or 1.300 acid as required to bring the specific gravity to between 1.270 and 1.280.

Adjusting the
Electrolyte
Replaced

Put the battery on charge at the low rate given on the name plate of each tray. Charge at about this rate until all of the cells gas uniformly. Reduce the current to about one-half and charge for about three hours longer, when the battery will be ready to put into service.

Freshening
Charge

It is advisable, however, before putting the battery into service to take and record the specific gravity of the electro-

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Pilot Cell Since, during a discharge, the drop in specific gravity of the electrolyte is directly proportional to the amount of the discharge, one of the cells of the battery may be regularly used as a "pilot cell" for taking hydrometer readings, which are of value to indicate the state of charge or discharge of the battery at any time.

Battery Idle When a battery is to remain idle for a period of not to exceed four months, see that it is in good condition and give it an equalizing charge immediately before the idle period and again immediately before going into service. If more than four months, send it to your battery man.

Leaking Jar If a jar develops a leak, have it replaced at once.

Periodical Inspection Decreasing specific gravity throughout the battery (*when not due to insufficient charging*), indicates that sediment is accumulating in the bottom of the jars. An inspection should be made by a competent battery man when the specific gravity of the *fully charged* battery is below 1.250.

"Exide" Inspection Service In territories covered by The Electric Storage Battery Company's Service Department, the Company will be glad to have an inspector, on one of his periodical trips, make an inspection free of charge.

If advice is desired, which cannot be obtained locally, write, giving full particulars and especially *all* markings on the name plate on the battery trays, to

THE ELECTRIC STORAGE BATTERY CO.

Service Department

333 W. 35th St.

Chicago, Ill.

or to

THE ELECTRIC STORAGE BATTERY CO.

Allegheny Ave. and 19th St.

Philadelphia, Pa.

or to

THE ELECTRIC STORAGE BATTERY CO.

590 Howard Street,

San Francisco, Cal.

Boosting

The term "boosting" as applied to vehicle batteries may be defined as "auxiliary charging." It usually implies a partial charge given in a comparatively short time and at current rates higher than normal. A battery may be boosted when fully discharged or when only partially discharged, although the latter case is more usual. Definition

Boosting is particularly adapted to commercial vehicles, and is applicable when the capacity required from a battery is greater than the normal output for which it is designed. Such conditions may arise from the necessity of doing extra work, as in the case of heavy delivery requirements during the Christmas rush or from bad weather or heavy roads. A battery may have ample capacity to give the desired mileage under normal conditions and by boosting can be made to meet extra demands. When Applicable

Boosting renders it unnecessary to carry around every day a battery capable of giving the special capacity occasionally required.

In considering boosting a battery, it should always be remembered that the limits for charging rate at any time are the gassing and temperature of the cells. The temperature should not be allowed to exceed 110° F. A battery on charge is absorbing all the current when it is not gassing, regardless of the rate of current. A battery in a considerably discharged condition will absorb current at a very high rate with neither gassing nor undue rise in temperature. A battery which is very little discharged will absorb current only at a very low rate.

There are several methods by which boosting can be practically applied to batteries of the "Exide" types, and the method to be chosen depends upon the available charging facilities and other conditions in individual cases.

1. **Constant Potential** (Fixed Voltage). Where conditions permit, this is probably the ideal method since it is entirely automatic and requires little attention. It is applicable where there is available a voltage of about 2.3 per cell of battery, for example, 110 volts for 48 cells, and the charge Constant Potential

ing equipment and wiring have sufficient capacity for current rates up to four or five times the usual charging rates. Where the voltage of the charging source is higher than 2.3 per cell, it may be cut down by placing in the charging circuit counter E. M. F. cells, figured at 3 volts each. (A rheostat will not accomplish the desired result.) Thus, if the line voltage is 110 and the battery consists of 40 cells, there will be 18 volts to be taken up by counter cells and six of these will be required.

With the charging voltage thus fixed at about 2.3 volts per cell, a battery in any state of discharge can be put on charge and will receive in a short time a large proportion of the amount of discharge which has been taken out. The current will automatically taper from a high rate at the start to a low rate toward the finish, and no attention or adjustment is required. Under normal conditions, the cells will not reach the free gassing point or excessive temperature, and therefore no harm will result from their being inadvertently left on charge longer than necessary.

2. Approximate Constant Potential, with Fixed Resistance in Series with the Battery. When the charging equipment and wiring have sufficient capacity for high currents as above, but the voltage of the charging circuit is too high (above 2.3 per cell) and counter E. M. F. cells are not available for cutting it down, the following method may be used providing the time is limited to one hour or less: Connect a rheostat in series with the battery with all the resistance in circuit. The rheostat must be capable of carrying currents up to four or five times the usual starting charge rate. After closing the circuit, read the voltage at the battery terminals and cut down the charging resistance until the battery voltage corresponds to the voltage given in the following table for the appropriate number of cells. The circuit can then be left without further adjustment for an hour or less and the current will taper off as the voltage of the battery rises. *This table is figured for a line voltage of 110-120, and the voltages given are too high for a boost of more than one hour's duration.*

BOOSTING

Number of Cells

Voltage at Battery Terminals

48	110
44	98
42	92
40	86
38	80

3. Constant Current. In some cases it is more convenient to give a boost at a constant rate of current, and as there is generally a limited time available, it is desirable to know under any given conditions what rate is safe. A convenient rule for determining this is as follows:

Charging current (amperes) = $\frac{\text{ampere hours already discharged}}{1 + \text{hours available for boosting.}}$ Constant Current

This gives the maximum current which can be used for the time specified without reaching the gassing point. The method is most conveniently applied where the car is equipped with an ampere hour meter.

In order to save calculations, we give a table based on this formula. Knowing the ampere hours discharged and the time available for boosting, the proper charging current, irrespective of the size of battery, can be read off at a glance.

When any considerable time for boosting is available and it is convenient to regulate the current at intervals, a greater amount of charge can be put in by dividing the time into several periods and finding the current for each period separately.

One of the methods outlined above is almost sure to meet the requirements of any individual case; but whatever method is used, remember:

To obtain the advantages of boosting without injury to the battery, **avoid gassing and keep the cell temperature below 110 degrees F.**

CONSTANT CURRENT BOOSTING RATES

Ampere Hours Discharged	TIME AVAILABLE FOR BOOSTING							
	¼ hour Amperes	½ hour Amperes	¾ hour Amperes	1 hour Amperes	1¼ hours Amperes	1½ hours Amperes	1¾ hours Amperes	2 hours Amperes
10	8	6	5	5	4	4	3	3
20	16	13	11	10	9	8	7	6
30	24	20	17	15	13	12	11	10
40	32	26	23	20	18	16	14	13
50	40	33	28	25	22	20	18	16
60	48	40	34	30	26	24	22	20
70	56	46	40	35	31	28	25	23
80	64	53	45	40	35	32	29	27
90	72	60	51	45	40	36	33	30
100	80	66	57	50	44	40	36	33
110	88	73	63	55	49	44	40	37
120	96	80	68	60	53	48	43	40
130	104	87	74	65	58	52	47	43
140	112	93	80	70	62	56	51	47
150	120	100	86	75	67	60	54	50
160	128	106	91	80	71	64	58	53
170	136	113	97	85	75	68	62	57
180	144	120	103	90	80	72	65	60
190	152	127	108	95	84	76	69	63
200	160	133	114	100	89	80	73	67
210	168	140	120	105	93	84	76	70
220	176	147	126	110	98	88	80	73
230	184	153	131	115	102	92	84	77
240	192	160	137	120	106	96	87	80
250	200	167	143	125	111	100	91	83

Explanation.—In the left hand column, find the figure nearest to the ampere hours discharged from the battery; follow across to the column headed by the available time. The figure at this intersection is the current to be used.

Example.—Ampere hour meter reading, 103 ampere hours discharged; time available for boosting, one hour. Start at 100 in the left hand column; follow across to the column headed 1 hour and find 50, which is the current to be used.

In general, the above method will not put in as much charge in a given time as the constant potential method, and the *current must not be continued beyond the time for which the rate is figured*, as injurious gassing and heating will result.

Replacing a Jar

To replace a broken jar, where the connector puller is not available, drill the connectors centrally in the top of the enlarged ends joined to the two cells adjacent to the jar which is to be replaced. A $\frac{5}{8}$ inch wood bit is suitable (Fig. 1). Before removing the cell, mark one of its connectors in order to replace the cell properly after the jar has been changed.

Removing
Connectors

Mark Polarity

Lift the complete cell, including jar, out of the tray (Fig. 2) and with an ordinary gasoline blow torch warm the

Part of connector cut away
to show depth of drilling

Cell to be
removed

Method of drilling
connector

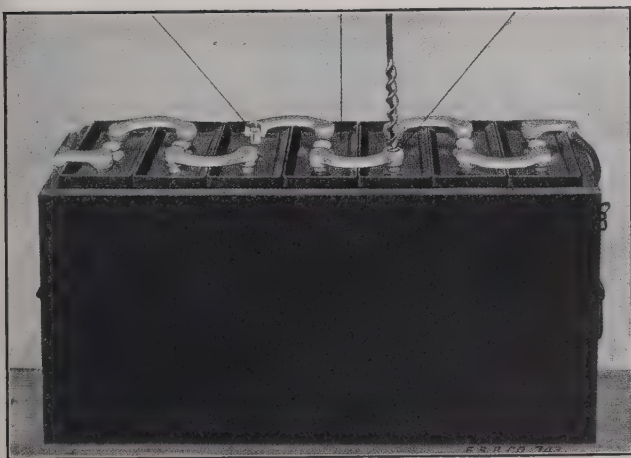


Fig. 1. Drilling off Connectors

sides of the jar around the top to soften the sealing compound around the cover (Fig. 3). Grip the jar between the feet, take hold of the two connectors and pull the element almost out of the jar (Fig. 4); then grip the element near the bottom (Fig. 5) in order to keep the plates from flaring out while transferring to the new jar, taking care not to let the outside plates start down over the outside of the jar (Fig. 6). After

Removing
Element
from Jar

Installing
Element in
New Jar

the element is in the new jar, reseal the cell by pressing the sealing compound into place with a hot putty knife.

Fill the cell with 1.250 electrolyte to the proper height.



Fig. 2. Lifting Cell out of Tray

Before replacing the connector, clean both the post and the inside of the eye of the connector by scraping smooth with a knife blade. When the connector has been placed in position, tap it down firmly over the post to insure good contact.

Reburning
Connectors

To complete the connection, melt the lead of the connector and the post at the top so that they will run together, and while the lead is still molten, melt in more until the eye of the

REPLACING A JAR

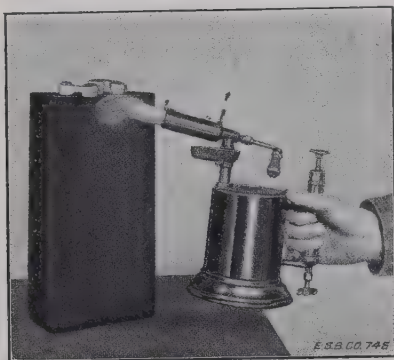


Fig. 3. Softening Sealing Compound on Cell

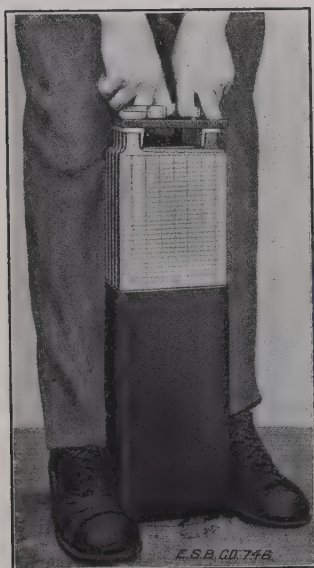


Fig. 4. Lifting Element out of Jar by Hand

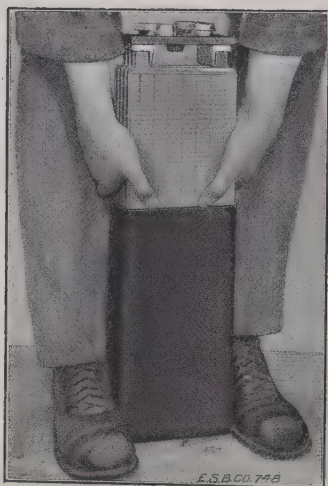


Fig. 5. Gripping Element near Bottom to Keep Plates from Flaring out

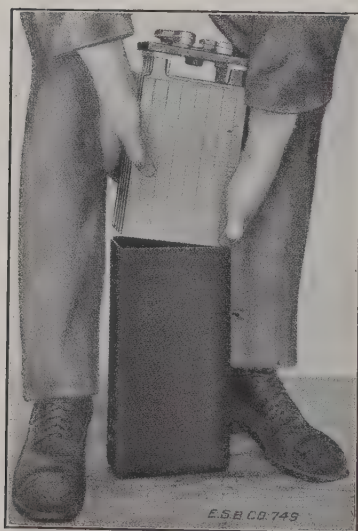
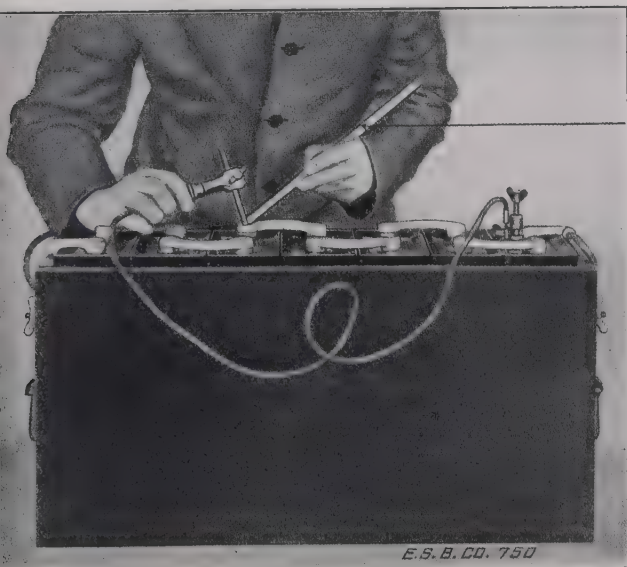


Fig 6. Installing Element in Jar

REPLACING A JAR



Lead
burning
strip

Fig. 7. Reburning Cell with Carbon Arc

connector is filled. This is called "lead burning," and can best be accomplished by means of a regular hydrogen flame if available; or with a carbon arc burning outfit, as shown in Fig. 7, or an ordinary soldering iron heated red hot and used as shown in Fig. 8.

Never use soldering flux of any kind.

Put the battery on charge, and when the cells begin to gas freely reduce the current to half the "finishing" rate given on the name plate and charge at this rate as long as there is any rise in gravity in this or any of the other cells. The maximum gravity has been reached when there has been no rise for a period of three hours. If the gravity of this one cell is then above 1.280, draw off some of the electrolyte and replace with

Adjusting
Gravity of
Electrolyte

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pure water. If the gravity is below 1.270, draw off some of the electrolyte and replace with 1.300 electrolyte. After putting in the 1.300, allow the battery to charge for about half an hour at a rate sufficient to cause gassing, which will cause the stronger acid to become mixed with the rest of the electrolyte in the cell.

Red hot
soldering
iron, not
tinned



Fig. 8. Reburning Cell with Soldering Iron

A Brief Outline of the Action in a Storage Battery During a Complete Cycle of Discharge and Charge

A storage battery consists of one or more cells.

A cell consists essentially of positive and negative plates immersed in electrolyte. General

The electrolyte of the "Exide" vehicle cell consists of a mixture of sulphuric acid and water which, when the cell is fully charged, should have a gravity of 1.270 to 1.280.

When a cell is put on discharge, the current is produced by the acid in the electrolyte going into and combining with the lead of the porous part of the plates called "active material." In the positive plate the active material is lead peroxide, and in the negative is metallic lead in a spongy form.

When the sulphuric acid in the electrolyte combines with the lead in the active material, a compound, lead sulphate, is formed. Formation of
Lead Sulphate

This lead sulphate is formed in the same way that sulphuric acid on the copper wiring or terminals forms "copper sulphate," or acid on the iron work of the car forms "iron sulphate." In this connection, it is noticeable that a comparatively large mass of "copper sulphate" or "iron sulphate" is formed on the metal work of the car when only a small quantity of the metal is eaten away. In the same manner, the sulphuric acid of the electrolyte combines with lead in the plates forming lead sulphate, which, on account of its increased volume, fills the pores of the active material.

As the discharge progresses, the electrolyte becomes weaker by the amount of acid that is used in the plates, producing the electric current and incidentally producing the compound of acid and lead called "lead sulphate." This sulphate continues to increase in quantity and bulk, thereby filling the pores of the plates. As the pores of the plates become thus filled with the sulphate, the free circulation of acid into the plates is retarded; and, since the acid cannot then get into the plates fast enough to maintain the normal Retarding
Circulation
of Acid

Drop in Voltage
End of Discharge

action, the battery becomes less active, as is indicated by a rapid drop in voltage. Experience teaches that at the normal discharge rate the voltage will begin to drop rapidly very soon after reaching 1.8 per cell. It is therefore advisable to stop the discharge when the voltage has dropped as low as 1.7 per cell, and a battery should not normally be discharged below this point.

Drop in Specific Gravity During Discharge

During a normal discharge the amount of acid used from the electrolyte in "Exide" types of cells will cause the gravity to drop 100 to 150 points. Thus, if the gravity of a fully charged cell is 1.275, it will, at the end of discharge, be between 1.175 and 1.125, depending upon the type of cell. The battery should be put on charge before it is discharged below this point.

Charging
Action of the Current

To charge, cause direct current to pass through the cells in a direction opposite to that of discharge. This current, passing through the cells in the reverse direction, will reverse the action which took place in the cells during discharge. It will be remembered that during discharge the acid of the electrolyte went into and combined with the active material, filling its pores with sulphate and causing the electrolyte to become weaker. Reversing the current through this sulphate in the plates restores the active material to its original condition and returns the acid to the electrolyte. Thus, during charge, the electrolyte gradually becomes stronger as the sulphate in the plates decreases, until no more sulphate remains and all the acid has been returned to the electrolyte, when it will be of the same strength as before the discharge and the same acid will be ready to be used over again during the next discharge. Since there is no loss of acid, none should ever be added to the electrolyte.

Object of Charging

Remember this: *The acid absorbed by the plates during discharge is, during charge, driven from the plates by the charging current and restored to the electrolyte. This is the whole object of charging.*

It has been said that every man has a different method of charging a storage battery, but in fact all methods are essen-

tially the same in principle; that is, to pass direct current through the cells in the right direction. In the use of this current, there are only two points to be considered—rate in amperes and time.

Different
Methods of
Charging

The rate in amperes is limited by the state of discharge. When a battery is fully discharged, at which time the plates contain the greatest amount of sulphate, it can utilize current at the highest rate. As the charge progresses and the amount of sulphate in the plates decreases, they can no longer utilize current at the same rate and the current should be reduced. The time at which to reduce the current is when the cells begin to give off gas.

Limit of
Charging Rate

The gassing of a cell is a feature of charging which has been very little regarded, but is of great importance. *Gassing shows at any time whether or not the charging rate is too high.*

Gassing

Current passing through an electrolyte will always do something. It will always do the easiest thing first. When current is passed through a discharged cell, the easiest thing is to decompose sulphate. As there is a comparatively large amount of sulphate in a fully discharged cell, a high rate of current can be used, but as the amount of sulphate decreases a point will be reached at which there will not be sufficient sulphate remaining in the plates to utilize all the current passing through. The excess current will then begin to do the next easiest thing, which is to decompose the water of the electrolyte, producing gas and, **therefore**, when the cells begin to gas freely, it indicates that current is being passed through the cells at too high a rate and the current should be lowered sufficiently to stop the gassing. As the charge is continued at the lower rate, the remaining sulphate will continue to decrease in amount until there is not sufficient left to utilize this rate of current and the cells will again begin to gas. The current should be lowered each time the gassing begins. When the cells begin to gas freely at a very low rate, it indicates that there is no sulphate remaining, so that even this very low rate of current cannot be utilized, and the charge is completed.

Cause
of Gassing

What Gassing
Indicates

The sulphating which takes place during an ordinary discharge is entirely normal. If, however, charging is neglected, the sulphate increases and becomes hard and the plates

Normal
Sulphate

Abnormal Sulphate lose their porosity and are not easily charged; this is the abnormal condition usually referred to as "sulphated."

Equalizing Charge In ordinary charging, there is not sufficient time to continue the charge until absolutely all the sulphate is removed. To prevent any possibility of the small remaining amount of sulphate increasing and becoming hard, a weekly equalizing charge is given.

Ampere Hour Capacity

The ampere hour capacity of a battery, the cells of which are connected in one series, is the same as that of a single cell in the series.

The ampere hour capacity of a cell depends upon the number of plates of a given type.

The ampere hour capacity of a plate depends upon the amount of available active material it contains.

It may be well to explain here what is meant by *available* active material. Since acid and lead combine with each other in a definite proportion in producing current, it might seem possible to have acid and lead in a cell in such quantities that both would be completely exhausted. Toward the end of the discharge, however, the electrolyte would be so weak that it would not be capable of producing current at a sufficient rate for any practical purpose. For this reason, it is necessary to have in the electrolyte acid in excess of the amount actually used in the plates during discharge.

Similarly, if all the active material were combined with acid, the plates would lose their porosity and conductivity, and an excess of lead active material is likewise provided.

It is customary to make both outside plates in a cell negatives. The cells contains, therefore, an odd number of plates and the capacity is fixed by the number of positives.

On this basis, the following table shows the rated capacities of the several types of M. V. "Exide" plates:

TYPE	Discharge Rate per Positive Plate	Time in Hours	Ampere Hours per Positive Plate
"Exide".....	7	4	28
"Ironclad=Exide"....	7	4.5	31.5
"Hycap=Exide".....	5.5	5	27.5
"Thin=Exide".....	4.125	6	24.75

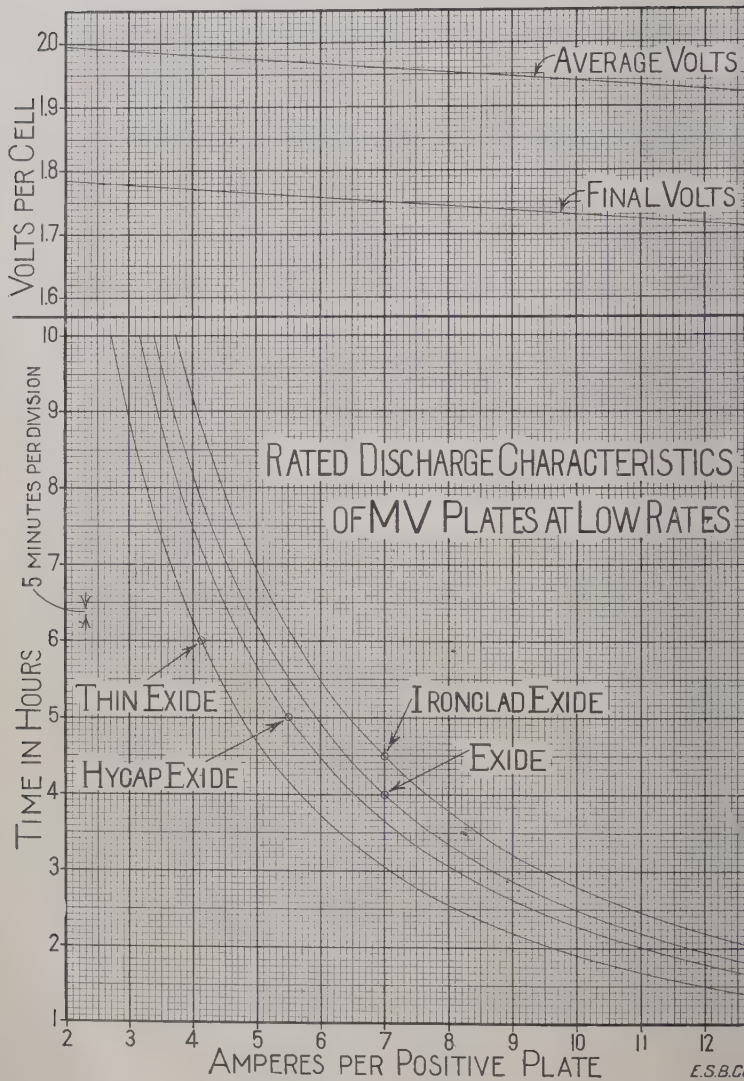
A. H. Capacity
of a Battery

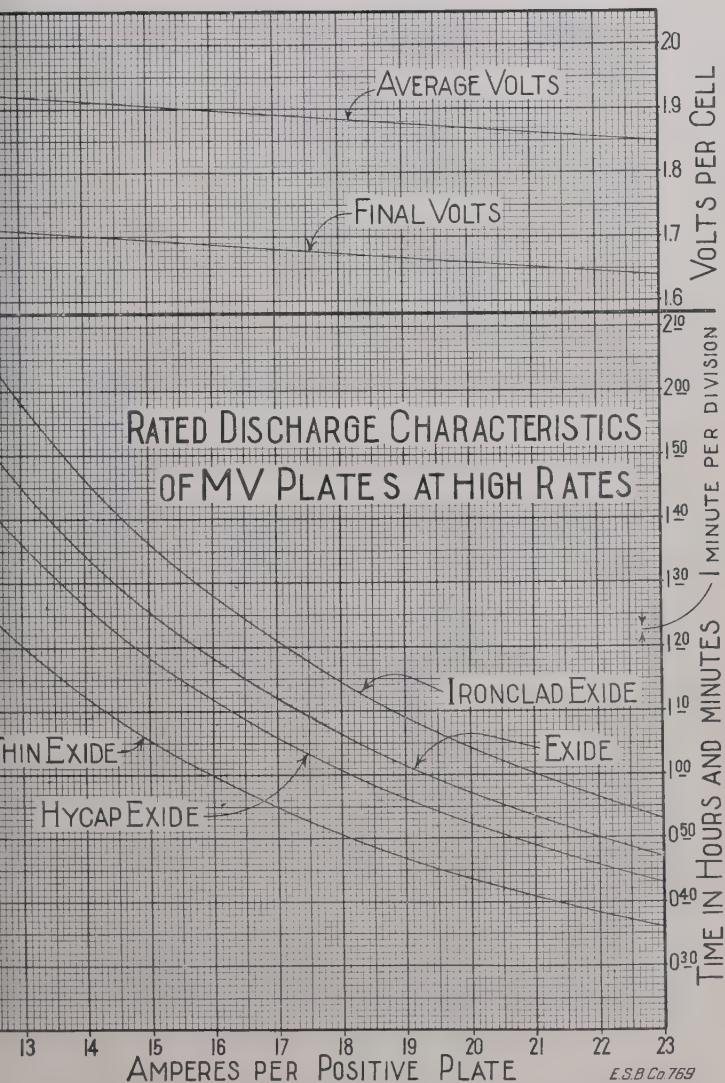
A. H. Capacity
of a Cell

A. H. Capacity
of a Plate

Available
Active
Material

Capacities
of M. V.
"Exide"
Plates





Rate of Discharge

General

Since the current is produced by the action of sulphuric acid combining with lead in the plates, the rate at which the acid can get to the material determines the maximum rate at which current can be produced. For instance, if the same amount of material in a nine plate cell were made into only two plates, one positive and one negative, the ampere hour capacity at a sufficiently low rate would be just the same as if this material were divided into four positives and five negatives. At ordinary rates of discharge, however, the acid could not get to the material of such a thick plate fast enough to maintain the rate for the required time. If these same thick plates were split into thinner plates, the acid could much more readily get to that portion of the material which in the thick plates was farther removed from the surface, and current could therefore be produced more rapidly. It is apparent that, within certain limits, the material can be divided into thinner and thinner plates to maintain the desired rate of discharge.

Thin Plates

The thinner the plates the shorter the life under ordinary conditions of service; therefore, it is always advisable to use

Thick Plates

as thick a plate as the necessary capacity at the required rate of discharge will permit.

The curves on pages 2 and 3 show the capacity and voltage characteristics of the various "Exide" types at different rates of discharge.

Electrolyte

Electrolyte, as used in all “**Exide**” types of batteries, consists of a mixture of pure sulphuric acid and distilled or other pure water.

Composition

Concentrated sulphuric acid is a heavy, oily liquid having a specific gravity of about 1.835. A battery will not operate if the acid is too strong, and it is therefore diluted with sufficient pure water to bring it to a gravity of about 1.275 for a fully charged battery.

Concentrated
Sulphuric
Acid

While a battery is being discharged, the electrolyte becomes weaker, as part of the acid is combined in the plates in producing the current.

This weakening of the electrolyte causes the gravity to drop 100 to 150 points during a complete discharge. During the charge, this acid is returned to the electrolyte, thus increasing its strength until it again reaches the normal gravity. There being no loss of acid, it is never necessary during normal service to add any acid to a battery. Of course, if a battery is upset and acid spilled, or if a jar is broken and acid leaks out, it should be replaced. In the event of any cells having been flooded, by wash water or other cause, provision should immediately be made to prevent a recurrence. *Unless acid is actually known to be lost out of a cell, none should ever be added during the entire life of a battery.* The amount of acid lost in spray is immeasurably small and should be neglected.

Drop in Specific Gravity

The gravity of the electrolyte need not necessarily be exact, but in a fully charged battery a range from 1.250 to 1.300 is permissible.

Both the water and the sulphuric acid used in making electrolyte should be chemically pure to a certain standard. This is the same standard of purity as is usually sold in drug stores as “CP” (chemically pure) or by the chemical manufacturers as “battery acid.”

Chemically
Pure
Electrolyte

In this connection, the expression “chemically pure” acid is often confused with acid of “full strength.” An acid may be of full strength (approximately 1.835 sp. gr.) and at the same time chemically pure. If this chemically pure acid of full strength be mixed with chemically pure water, the mixture would still be chemically pure, but not of full strength. On

Counter
E. M. F. Cells

ing equipment and wiring have sufficient capacity for current rates up to four or five times the usual charging rates. Where the voltage of the charging source is higher than 2.3 per cell, it may be cut down by placing in the charging circuit counter E. M. F. cells, figured at 3 volts each. (A rheostat will not accomplish the desired result.) Thus, if the line voltage is 110 and the battery consists of 40 cells, there will be 18 volts to be taken up by counter cells and six of these will be required.

Tapering
Current

With the charging voltage thus fixed at about 2.3 volts per cell, a battery in any state of discharge can be put on charge and will receive in a short time a large proportion of the amount of discharge which has been taken out. The current will automatically taper from a high rate at the start to a low rate toward the finish, and no attention or adjustment is required. Under normal conditions, the cells will not reach the free gassing point or excessive temperature, and therefore no harm will result from their being inadvertently left on charge longer than necessary.

Approximate
Constant
Potential

Rheostat

2. Approximate Constant Potential, with Fixed Resistance in Series with the Battery. When the charging equipment and wiring have sufficient capacity for high currents as above, but the voltage of the charging circuit is too high (above 2.3 per cell) and counter E. M. F. cells are not available for cutting it down, the following method may be used providing the time is limited to one hour or less: Connect a rheostat in series with the battery with all the resistance in circuit. The rheostat must be capable of carrying currents up to four or five times the usual starting charge rate. After closing the circuit, read the voltage at the battery terminals and cut down the charging resistance until the battery voltage corresponds to the voltage given in the following table for the appropriate number of cells. The circuit can then be left without further adjustment for an hour or less and the current will taper off as the voltage of the battery rises. *This table is figured for a line voltage of 110-120, and the voltages given are too high for a boost of more than one hour's duration.*

BOOSTING

Number of Cells	Voltage at Battery Terminals
48	110
44	98
42	92
40	86
38	80

3. Constant Current. In some cases it is more convenient to give a boost at a constant rate of current, and as there is generally a limited time available, it is desirable to know under any given conditions what rate is safe. A convenient rule for determining this is as follows:

Charging current (amperes) $\frac{\text{ampere hours already discharged}}{1 \mid \text{hours available for boosting.}}$ Constant Current Formula

This gives the maximum current which can be used for the time specified without reaching the gassing point. The method is most conveniently applied where the car is equipped with an ampere hour meter.

In order to save calculations, we give a table based on this formula. Knowing the ampere hours discharged and the time available for boosting, the proper charging current, irrespective of the size of battery, can be read off at a glance.

When any considerable time for boosting is available and it is convenient to regulate the current at intervals, a greater amount of charge can be put in by dividing the time into several periods and finding the current for each period separately.

One of the methods outlined above is almost sure to meet the requirements of any individual case; but whatever method is used, remember:

To obtain the advantages of boosting without injury to the battery, **avoid gassing and keep the cell temperature below 110 degrees F.**

CONSTANT CURRENT BOOSTING RATES

Ampere Hours Discharged	TIME AVAILABLE FOR BOOSTING							
	$\frac{1}{4}$ hour Amperes	$\frac{1}{2}$ hour Amperes	$\frac{3}{4}$ hour Amperes	1 hour Amperes	$1\frac{1}{4}$ hours Amperes	$1\frac{1}{2}$ hours Amperes	$1\frac{3}{4}$ hours Amperes	2 hours Amperes
10	8	6	5	5	4	4	3	3
20	16	13	11	10	9	8	7	6
30	24	20	17	15	13	12	11	10
40	32	26	23	20	18	16	14	13
50	40	33	28	25	22	20	18	16
60	48	40	34	30	26	24	22	20
70	56	46	40	35	31	28	25	23
80	64	53	45	40	35	32	29	27
90	72	60	51	45	40	36	33	30
100	80	66	57	50	44	40	36	33
110	88	73	63	55	49	44	40	37
120	96	80	68	60	53	48	43	40
130	104	87	74	65	58	52	47	43
140	112	93	80	70	62	56	51	47
150	120	100	86	75	67	60	54	50
160	128	106	91	80	71	64	58	53
170	136	113	97	85	75	68	62	57
180	144	120	103	90	80	72	65	60
190	152	127	108	95	84	76	69	63
200	160	133	114	100	89	80	73	67
210	168	140	120	105	93	84	76	70
220	176	147	126	110	98	88	80	73
230	184	153	131	115	102	92	84	77
240	192	160	137	120	106	96	87	80
250	200	167	143	125	111	100	91	83

Explanation.—In the left hand column, find the figure nearest to the ampere hours discharged from the battery; follow across to the column headed by the available time. The figure at this intersection is the current to be used.

Example.—Ampere hour meter reading, 103 ampere hours discharged; time available for boosting, one hour. Start at 100 in the left hand column; follow across to the column headed 1 hour and find 50, which is the current to be used.

In general, the above method will not put in as much charge in a given time as the constant potential method, and the *current must not be continued beyond the time for which the rate is figured*, as injurious gassing and heating will result.

Replacing a Jar

To replace a broken jar, where the connector puller is not available, drill the connectors centrally in the top of the enlarged ends joined to the two cells adjacent to the jar which is to be replaced. A $\frac{5}{8}$ inch wood bit is suitable (Fig. 1). Before removing the cell, mark one of its connectors in order to replace the cell properly after the jar has been changed.

Removing
Connectors

Mark Polarity

Lift the complete cell, including jar, out of the tray (Fig. 2) and with an ordinary gasoline blow torch warm the

Part of connector cut away
to show depth of drilling

Cell to be
removed

Method of drilling
connector

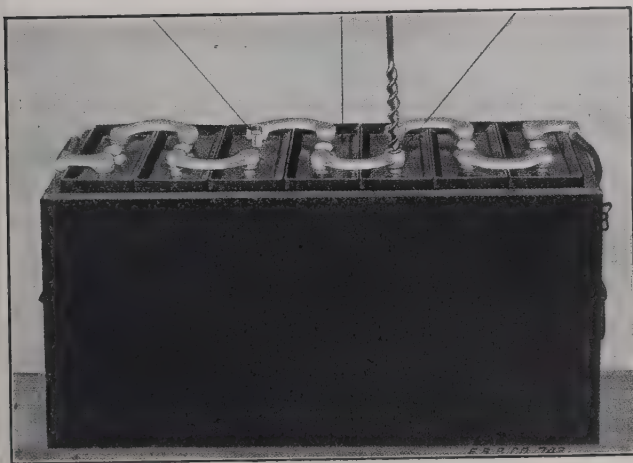


Fig. 1. Drilling off Connectors

sides of the jar around the top to soften the sealing compound around the cover (Fig. 3). Grip the jar between the feet, take hold of the two connectors and pull the element almost out of the jar (Fig. 4); then grip the element near the bottom (Fig. 5) in order to keep the plates from flaring out while transferring to the new jar, taking care not to let the outside plates start down over the outside of the jar (Fig. 6). After

Removing
Element
from Jar

Installing
Element in
New Jar

the element is in the new jar, reseal the cell by pressing the sealing compound into place with a hot putty knife.

Fill the cell with 1.250 electrolyte to the proper height.



Fig. 2. Lifting Cell out of Tray

Before replacing the connector, clean both the post and the inside of the eye of the connector by scraping smooth with a knife blade. When the connector has been placed in position, tap it down firmly over the post to insure good contact.

Reburning
Connectors

To complete the connection, melt the lead of the connector and the post at the top so that they will run together, and while the lead is still molten, melt in more until the eye of the

REPLACING A JAR

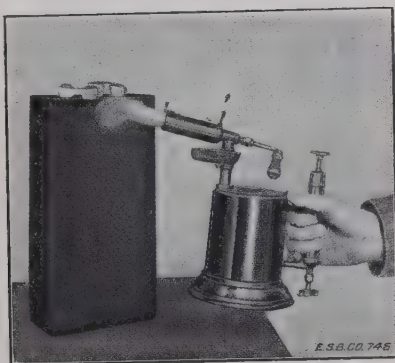


Fig. 3. Softening Sealing Compound on Cell

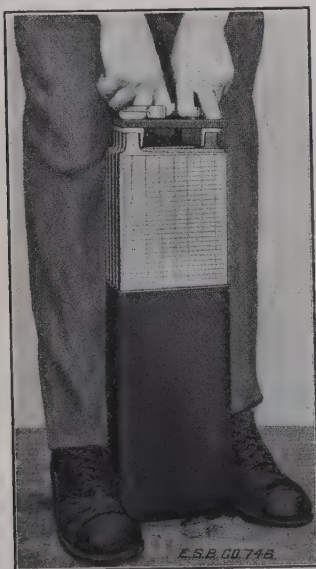


Fig. 4. Lifting Element out of Jar by Hand

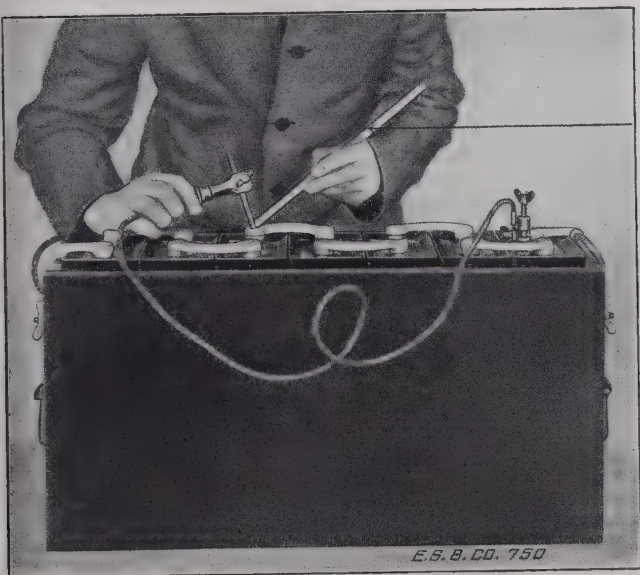


Fig. 5. Gripping Element near Bottom to Keep Plates from Flaring out



Fig 6. Installing Element in Jar

REPLACING A JAR



Lead
burning
strip

Fig. 7. Reburning Cell with Carbon Arc

connector is filled. This is called "lead burning," and can best be accomplished by means of a regular hydrogen flame if available; or with a carbon arc burning outfit, as shown in Fig. 7, or an ordinary soldering iron heated red hot and used as shown in Fig. 8.

Never use soldering flux of any kind.

Put the battery on charge, and when the cells begin to gas freely reduce the current to half the "finishing" rate given on the name plate and charge at this rate as long as there is any rise in gravity in this or any of the other cells. The maximum gravity has been reached when there has been no rise for a period of three hours. If the gravity of this one cell is then above 1.280, draw off some of the electrolyte and replace with

Adjusting
Gravity of
Electrolyte

MANUAL OF "Exide" BATTERIES IN ELECTRIC VEHICLES

pure water. If the gravity is below 1.270, draw off some of the electrolyte and replace with 1.300 electrolyte. After putting in the 1.300, allow the battery to charge for about half an hour at a rate sufficient to cause gassing, which will cause the stronger acid to become mixed with the rest of the electrolyte in the cell.

Red hot
soldering
iron, not
tinned



Fig. 8. Reburning Cell with Soldering Iron

A Brief Outline of the Action in a Storage Battery During a Complete Cycle of Discharge and Charge

A storage battery consists of one or more cells.

A cell consists essentially of positive and negative plates immersed in electrolyte. General

The electrolyte of the "Exide" vehicle cell consists of a mixture of sulphuric acid and water which, when the cell is fully charged, should have a gravity of 1.270 to 1.280.

When a cell is put on discharge, the current is produced by the acid in the electrolyte going into and combining with the lead of the porous part of the plates called "active material." In the positive plate the active material is lead peroxide, and in the negative is metallic lead in a spongy form.

When the sulphuric acid in the electrolyte combines with the lead in the active material, a compound, lead sulphate, is formed. Formation of
Lead Sulphate

This lead sulphate is formed in the same way that sulphuric acid on the copper wiring or terminals forms "copper sulphate," or acid on the iron work of the car forms "iron sulphate." In this connection, it is noticeable that a comparatively large mass of "copper sulphate" or "iron sulphate" is formed on the metal work of the car when only a small quantity of the metal is eaten away. In the same manner, the sulphuric acid of the electrolyte combines with lead in the plates forming lead sulphate, which, on account of its increased volume, fills the pores of the active material.

As the discharge progresses, the electrolyte becomes weaker by the amount of acid that is used in the plates, producing the electric current and incidentally producing the compound of acid and lead called "lead sulphate." This sulphate continues to increase in quantity and bulk, thereby filling the pores of the plates. As the pores of the plates become thus filled with the sulphate, the free circulation of acid into the plates is retarded; and, since the acid cannot then get into the plates fast enough to maintain the normal Retarding
Circulation
of Acid

action, the battery becomes less active, as is indicated by a rapid drop in voltage. Experience teaches that at the normal discharge rate the voltage will begin to drop rapidly very soon after reaching 1.8 per cell. It is therefore advisable to stop the discharge when the voltage has dropped as low as 1.7 per cell, and a battery should not normally be discharged below this point.

During a normal discharge the amount of acid used from the electrolyte in "Exide" types of cells will cause the gravity to drop 100 to 150 points. Thus, if the gravity of a fully charged cell is 1.275, it will, at the end of discharge, be between 1.175 and 1.125, depending upon the type of cell. The battery should be put on charge before it is discharged below this point.

To charge, cause direct current to pass through the cells in a direction opposite to that of discharge. This current, passing through the cells in the reverse direction, will reverse the action which took place in the cells during discharge. It will be remembered that during discharge the acid of the electrolyte went into and combined with the active material filling its pores with sulphate and causing the electrolyte to become weaker. Reversing the current through this sulphate in the plates restores the active material to its original condition and returns the acid to the electrolyte. Thus, during charge, the electrolyte gradually becomes stronger as the sulphate in the plates decreases, until no more sulphate remains and all the acid has been returned to the electrolyte, when it will be of the same strength as before the discharge and the same acid will be ready to be used over again during the next discharge. Since there is no loss of acid, none should ever be added to the electrolyte.

Remember this: *The acid absorbed by the plates during discharge is, during charge, driven from the plates by the charging current and restored to the electrolyte. This is the whole object of charging.*

It has been said that every man has a different method of charging a storage battery, but in fact all methods are essen-

BRIEF OUTLINE OF ACTION OF A STORAGE BATTERY

tially the same in principle; that is, to pass direct current through the cells in the right direction. In the use of this current, there are only two points to be considered—rate in amperes and time.

Different
Methods of
Charging

The rate in amperes is limited by the state of discharge. When a battery is fully discharged, at which time the plates contain the greatest amount of sulphate, it can utilize current at the highest rate. As the charge progresses and the amount of sulphate in the plates decreases, they can no longer utilize current at the same rate and the current should be reduced. The time at which to reduce the current is when the cells begin to give off gas.

Limit of
Charging Rate

The gassing of a cell is a feature of charging which has been very little regarded, but is of great importance. *Gassing shows at any time whether or not the charging rate is too high.*

Gassing

Current passing through an electrolyte will always do something. It will always do the easiest thing first. When current is passed through a discharged cell, the easiest thing is to decompose sulphate. As there is a comparatively large amount of sulphate in a fully discharged cell, a high rate of current can be used, but as the amount of sulphate decreases a point will be reached at which there will not be sufficient sulphate remaining in the plates to utilize all the current passing through. The excess current will then begin to do the next easiest thing, which is to decompose the water of the electrolyte, producing gas and, therefore, when the cells begin to gas freely, it indicates that current is being passed through the cells at too high a rate and the current should be lowered sufficiently to stop the gassing. As the charge is continued at the lower rate, the remaining sulphate will continue to decrease in amount until there is not sufficient left to utilize this rate of current and the cells will again begin to gas. The current should be lowered each time the gassing begins. When the cells begin to gas freely at a very low rate, it indicates that there is no sulphate remaining, so that even this very low rate of current cannot be utilized, and the charge is completed.

Cause
of Gassing

What Gassing
Indicates

The sulphating which takes place during an ordinary discharge is entirely normal. If, however, charging is neglected, the sulphate increases and becomes hard and the plates

Normal
Sulphate

Abnormal Sulphate lose their porosity and are not easily charged; this is the abnormal condition usually referred to as "sulphated."

Equalizing Charge In ordinary charging, there is not sufficient time to continue the charge until absolutely all the sulphate is removed. To prevent any possibility of the small remaining amount of sulphate increasing and becoming hard, a weekly equalizing charge is given.

Ampere Hour Capacity

The ampere hour capacity of a battery, the cells of which are connected in one series, is the same as that of a single cell in the series. A. H. Capacity of a Battery

The ampere hour capacity of a cell depends upon the number of plates of a given type. A. H. Capacity of a Cell

The ampere hour capacity of a plate depends upon the amount of available active material it contains. A. H. Capacity of a Plate

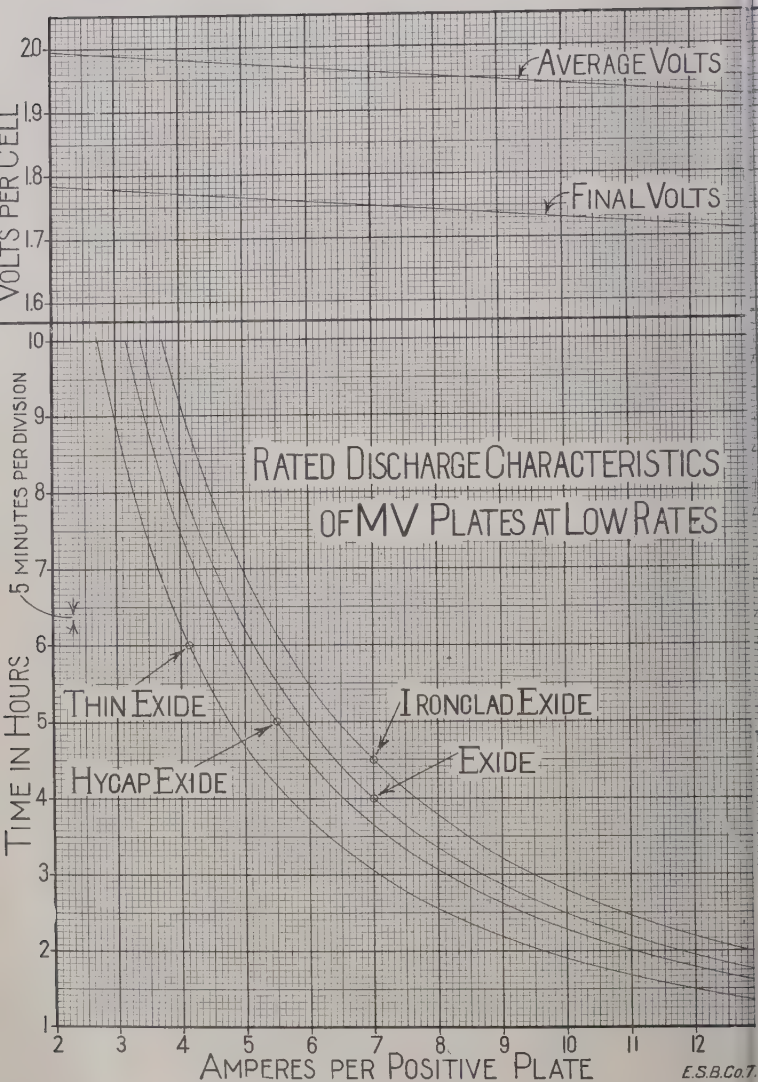
It may be well to explain here what is meant by *available* active material. Since acid and lead combine with each other in a definite proportion in producing current, it might seem possible to have acid and lead in a cell in such quantities that both would be completely exhausted. Toward the end of the discharge, however, the electrolyte would be so weak that it would not be capable of producing current at a sufficient rate for any practical purpose. For this reason, it is necessary to have in the electrolyte acid in excess of the amount actually used in the plates during discharge. Available Active Material

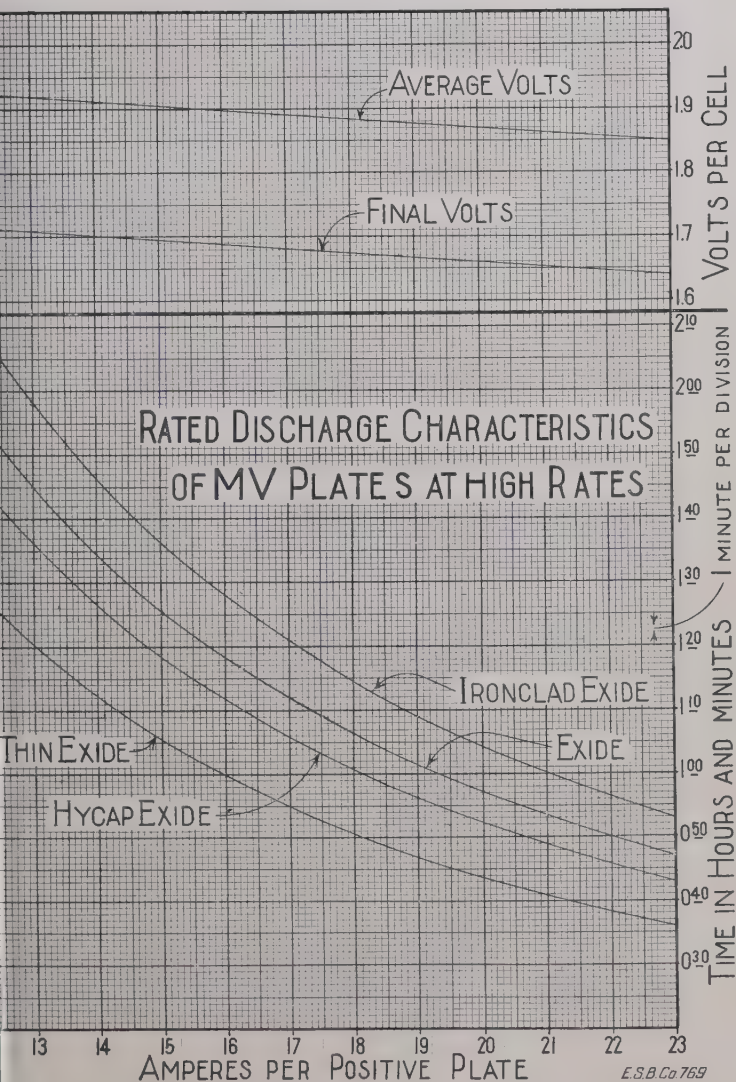
Similarly, if all the active material were combined with acid, the plates would lose their porosity and conductivity, and an excess of lead active material is likewise provided.

It is customary to make both outside plates in a cell negatives. The cells contains, therefore, an odd number of plates and the capacity is fixed by the number of positives.

On this basis, the following table shows the rated capacities of the several types of M. V. "Exide" plates: Capacities of M. V. "Exide" Plates

TYPE	Discharge Rate per Positive Plate	Time in Hours	Ampere Hours per Positive Plate
"Exide".....	7	4	28
"Ironclad=Exide"....	7	4.5	31.5
"Hycap=Exide".....	5.5	5	27.5
"Tbin=Exide".....	4.125	6	24.75





Rate of Discharge

General

Since the current is produced by the action of sulphuric acid combining with lead in the plates, the rate at which the acid can get to the material determines the maximum rate at which current can be produced. For instance, if the same amount of material in a nine plate cell were made into only two plates, one positive and one negative, the ampere hour capacity at a sufficiently low rate would be just the same as if this material were divided into four positives and five negatives. At ordinary rates of discharge, however, the acid could not get to the material of such a thick plate fast enough to maintain the rate for the required time. If these same thick plates were split into thinner plates, the acid could much more readily get to that portion of the material which in the thick plates was farther removed from the surface, and current could therefore be produced more rapidly. It is apparent that, within certain limits, the material can be divided into thinner and thinner plates to maintain the desired rate of discharge.

Thin Plates

The thinner the plates the shorter the life under ordinary conditions of service; therefore, it is always advisable to use

Thick Plates

as thick a plate as the necessary capacity at the required rate of discharge will permit.

The curves on pages 2 and 3 show the capacity and voltage characteristics of the various "Exide" types at different rates of discharge.

Electrolyte

Electrolyte, as used in all “**Exide**” types of batteries, consists of a mixture of pure sulphuric acid and distilled or other pure water.

Composition

Concentrated sulphuric acid is a heavy, oily liquid having a specific gravity of about 1.835. A battery will not operate if the acid is too strong, and it is therefore diluted with sufficient pure water to bring it to a gravity of about 1.275 for a fully charged battery.

Concentrated
Sulphuric
Acid

While a battery is being discharged, the electrolyte becomes weaker, as part of the acid is combined in the plates in producing the current.

This weakening of the electrolyte causes the gravity to drop 100 to 150 points during a complete discharge. During the charge, this acid is returned to the electrolyte, thus increasing its strength until it again reaches the normal gravity. There being no loss of acid, it is never necessary during normal service to add any acid to a battery. Of course, if a battery is upset and acid spilled, or if a jar is broken and acid leaks out, it should be replaced. In the event of any cells having been flooded, by wash water or other cause, provision should immediately be made to prevent a recurrence. *Unless acid is actually known to be lost out of a cell, none should ever be added during the entire life of a battery.* The amount of acid lost in spray is immeasurably small and should be neglected.

Drop in Specific Gravity

The gravity of the electrolyte need not necessarily be exact, but in a fully charged battery a range from 1.250 to 1.300 is permissible.

Both the water and the sulphuric acid used in making electrolyte should be chemically pure to a certain standard. This is the same standard of purity as is usually sold in drug stores as “CP” (chemically pure) or by the chemical manufacturers as “battery acid.”

Chemically
Pure
Electrolyte

In this connection, the expression “chemically pure” acid is often confused with acid of “full strength.” An acid may be of full strength (approximately 1.835 sp. gr.) and at the same time chemically pure. If this chemically pure acid of full strength be mixed with chemically pure water, the mixture would still be chemically pure, but not of full strength. On

the other hand, if a small quantity of some impurity be introduced into chemically pure acid, it would not materially reduce the strength, but would make it impure.

The usual method of determining the strength of electrolyte is by taking its specific gravity. This method is possible on account of the fact that sulphuric acid is heavier than water. Therefore the greater the proportion of acid contained in the electrolyte the heavier the solution or the higher its gravity.

Specific Gravity By specific gravity is meant the relative weight of any substance compared with water as a basis. Pure water, therefore, is considered to have a gravity of 1. One pound of water is approximately 1 pint. An equal volume of ordinary chemically pure sulphuric acid weighs 1.835 pounds. It therefore has a specific gravity of 1.835 and is spoken of as "eighteen thirty-five." As it is customary to carry the gravity readings out three decimal places, the gravity of water which is 1, is written 1.000 and spoken of as "one thousand."

Temperature Correction Since electrolyte, like most substances, expands when heated, its specific gravity is affected by a change in temperature. If electrolyte has a certain gravity at a temperature of 70° F. and be heated, the heat will cause the electrolyte to expand and, although the actual strength of the solution will remain the same as before heating, yet the expansion will cause it to have a lower gravity, of approximately one point (.001) for each three degrees rise in temperature. For instance, if electrolyte has a gravity of 1.275 at 70° F. and the temperature be raised to 73° F., this increase in temperature will cause the electrolyte to expand and the gravity to drop from 1.275 to 1.274. On the other hand, if the temperature had been lowered from 70° to 67° F., this would have caused the gravity to rise from 1.275 to 1.276. Since change of temperature does not alter the actual strength of the electrolyte, changing its gravity only, the gravity reading should be corrected one point for each three degrees change in temperature. For convenience, 70° F. is considered as normal, from which point the corrections are made.

ELECTROLYTE

The following table shows the parts of water by volume, the parts of water by weight and the percentage of acid to water to produce different gravities:

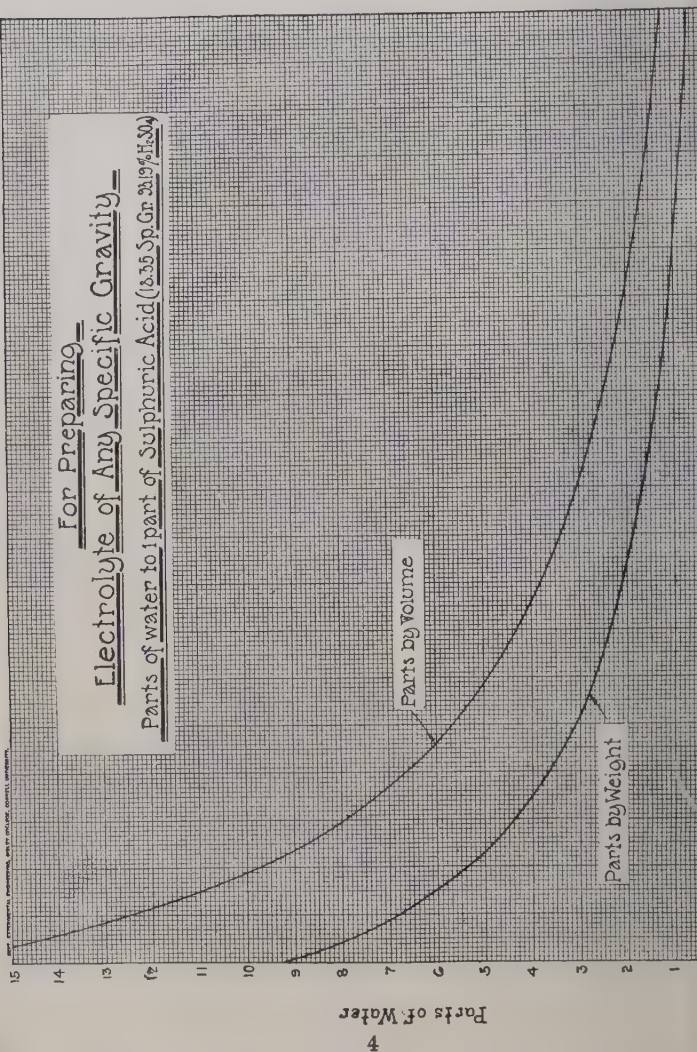
TABLE OF SULPHURIC ACID SOLUTIONS

Based on one part acid of 1.835 sp. gr. at 60° F.

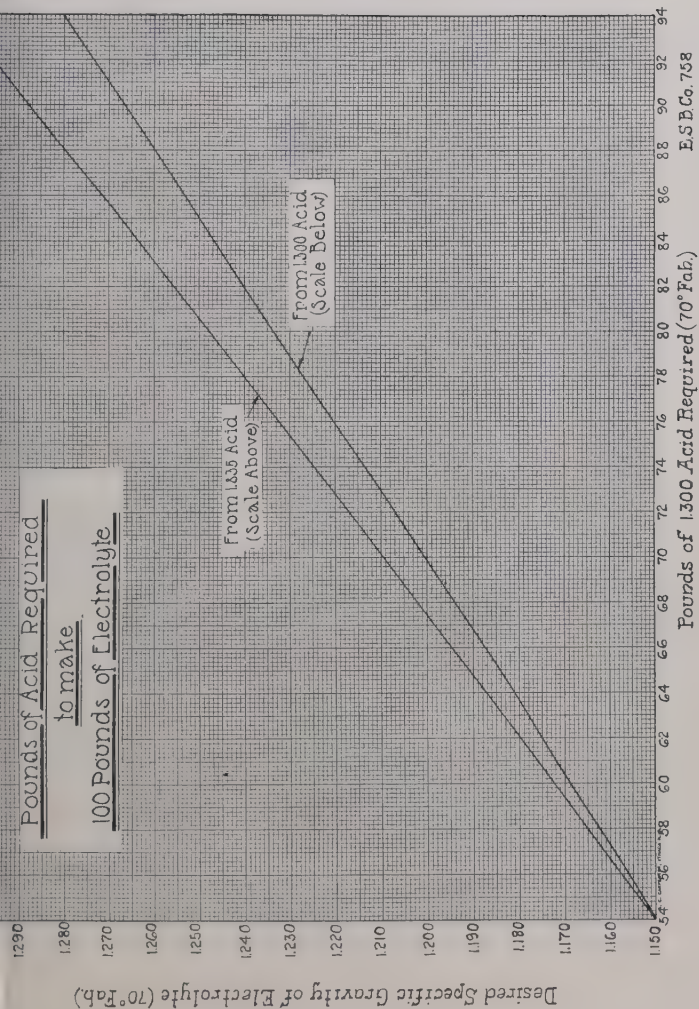
Table of Sulphuric Acid Solution

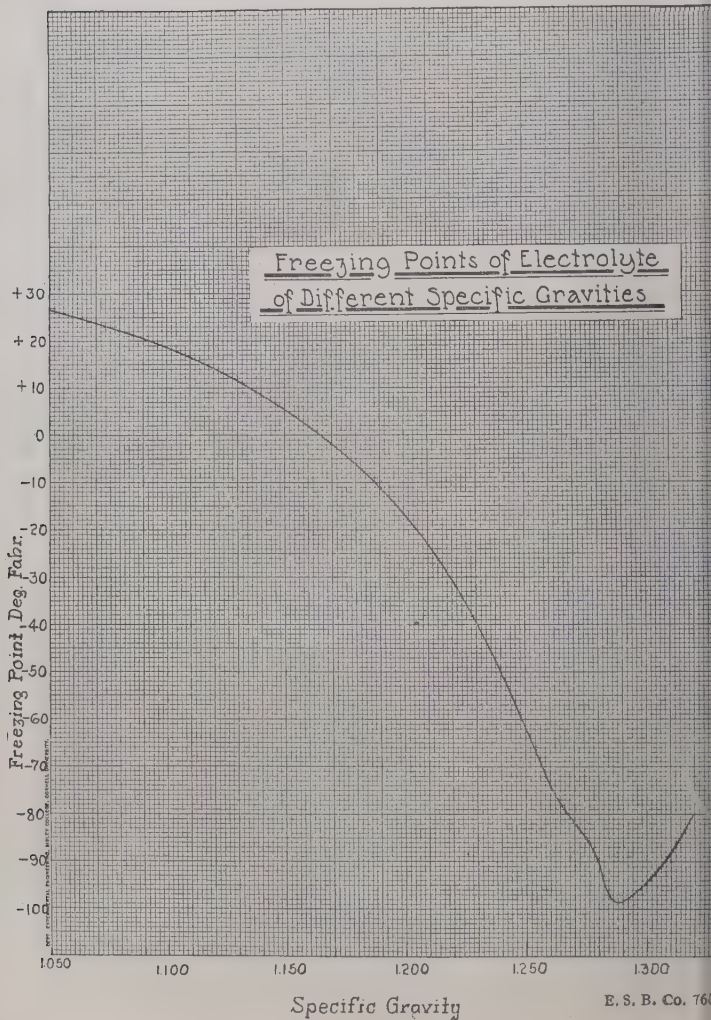
Specific Gravity of Solution (70° F.)	Parts of Water to One Part Acid		Percentage of Sulphuric Acid in Solution
	By Volume	By Weight	
1.100	9.8	5.4	14.65
1.110	8.8	4.84	16.
1.120	8.	4.4	17.4
1.130	7.28	3.98	18.8
1.140	6.68	3.63	20.1 ✓
1.150	6.15	3.35	21.4
1.160	5.7	3.11	22.7
1.170	5.3	2.9	24.
1.180	4.95	2.7	25.2
1.190	4.62	2.52	26.5
1.200	4.33	2.36	27.7
1.210	4.07	2.22	29.
1.220	3.84	2.09	30.2 ✓
1.230	3.6	1.97	31.4
1.240	3.4	1.86	32.5
1.250	3.22	1.76	33.7
1.260	3.05	1.66	35.
1.270	2.9	1.57	36.1
1.280	2.75	1.49	37.3
1.290	2.6	1.41	38.5
1.300	2.47	1.34	39.65 ✓
1.320	2.24	1.22	42.
1.340	2.04	1.11	44.1
1.360	1.86	1.01	46.3
1.380	1.7	.92	48.4
1.400	1.56	.84	50.5 ✓
1.450	1.25	.68	55.5
1.500	1.	.55	60.15 ✓
1.550	.8	.44	64.6
1.600	.639	.348	69.12 ✓
1.650	.497	.27	73.32
1.700	.369	.201	77.6
1.750	.248	.135	82.1 ✓
1.800	.1192	.0646	87.5
1.835	0.	0.	93.19 ✓

For Preparing—
Electrolyte of Any Specific Gravity—
Parts of water to 1 part of Sulphuric Acid (1.835 Sp. Gr. 20.9% H₂SO₄)



ELECTROLYTE





The Hydrometer and Its Use

Fig. 1 shows the several types of hydrometers in general use, and parallel with the stem of each is shown a view of the scale contained in the stem.

Types in
General Use

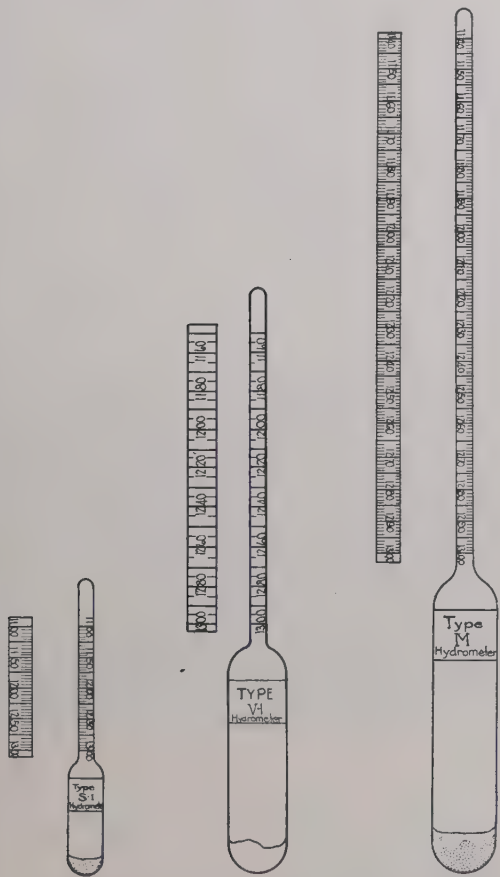


Fig. 1. Outlines of Hydrometers

E. S. B. Co. 761

Type V-1 is more commonly used in connection with vehicle types of batteries. Type S-1 is used with automobile starting and lighting batteries, and Type M is used in battery rooms where more accurate reading is desired.

It is necessary to have the electrolyte in a suitable vessel in which to place the hydrometer. The simpler form of vessel is a glass cylinder of sufficient diameter to allow the hydrometer to float freely without touching the sides and a little higher than the total length of the hydrometer. The hydrometer is placed in the cylinder and some acid is drawn from the cell with a syringe and placed in the cylinder, putting in just sufficient to float the hydrometer off the bottom of the cylinder.

Retaining
Vessel

Cylinder

This is shown in Fig. 2, and is sufficiently convenient where only occasional readings are taken, but where it is

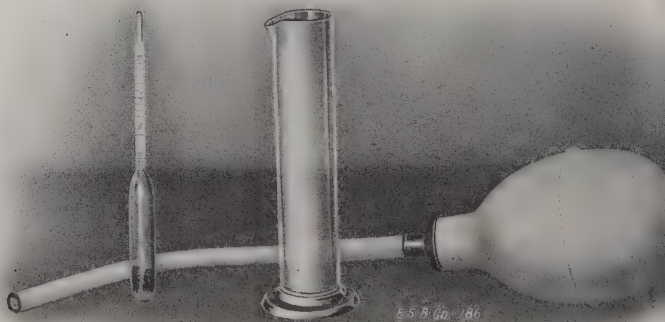


Fig. 2. Acid Testing Set

Syringe

desired to take frequent readings it is found more convenient to have a hydrometer placed inside of a glass barrel with a rubber bulb on the top end and a suitable nozzle on the lower end (Fig. 3). By squeezing the bulb, inserting the nozzle into the electrolyte and releasing the bulb, acid is

drawn up into the glass barrel. Draw up just sufficient to float the hydrometer off the rubber packing in the bottom of the glass barrel. This type and arrangement is most commonly used on account of the greater convenience in handling and on account of being able to make the readings more rapidly with less liability of spilling acid or getting it on the hands.

To prevent the hydrometer from sticking to the side of the barrel, it is necessary that it be held in a vertical position. As some cells in some makes of cars are so situated that the hydrometer cannot be held in a vertical position while the nozzle is still held in the vent hole of the cell, the soft rubber plug in the bottom of the glass barrel is arranged in the form of a trap, so that, when sufficient acid has been drawn into the barrel, the hydrometer nozzle can be removed from the vent hole and held in a vertical position, and the acid will not run out while the reading is being taken.

In recording the gravity of the different cells, it is customary to number the cells consecutively, beginning with the positive cell in the front compartment of the car and following the cells in the order of the electric circuit. If the trays are to be removed from the car, the same order of cells can be maintained by numbering them in the same order; that is, beginning with the positive tray in the front compartment of the car, mark it No. 1, and so on through the entire battery, following the electric circuit.

As soon as sufficient electrolyte has been drawn into the glass barrel to float the hydrometer, care being taken that it does not stick to the sides of the barrel, note underneath the level of the electrolyte the graduation on the stem of the hydrometer. Reading the hydrometer by looking underneath

Type V-1
and Its Use



Fig. 3

Type V-1 Hydrometer
Syringe, Complete

the level of the liquid is usually more accurate than readings taken by observing above the level.

By having a gravity record form tacked to a suitable board and placed on the fender of the car, one person can easily take the gravity readings with the left hand and note the readings on the form with the right hand, and in this way avoid getting any acid on the record form.

When the readings have been taken and recorded, be careful to put the acid back into the same cell from which it was taken. Failure to do this often leads to trouble. That is, acid is often taken out of one cell, the gravity noted and the acid put back into another cell. The result is that the amount of acid taken out of the first cell is eventually replaced with water, leaving the electrolyte weaker; whereas the acid which was taken out and put into the other cell would make the electrolyte of that cell stronger, resulting in an irregularity in the different cells.

As the battery is discharged the gravity of the electrolyte becomes less on account of a portion of the sulphuric acid contained in the electrolyte being used up in the plates in producing the current. In this way, during the normal discharge, the gravity drops about 100 to 150 points, depending on the type of the cell. So that, by noting the gravity of the electrolyte at any time and comparing it with the gravity at full charge, the state of charge at any time can be approximately determined.

As explained under "Electrolyte," while the gravity of an electrolyte depends principally on the proportions of sulphuric acid and water of which it is composed, another condition also affects the specific gravity slightly, and that is temperature. The gravity of the electrolyte is assumed to be correct when the readings are taken at a temperature of 70° F. The gravity becomes one point heavier for each three degrees below 70°; also one point lighter for each three degrees above 70°.

For the convenience of the operator, a thermometer has been designed with a special scale on the opposite side of the mercury column and parallel to the regular scale on which the amount of correction is indicated. That is, opposite to

THE HYDROMETER AND ITS USE

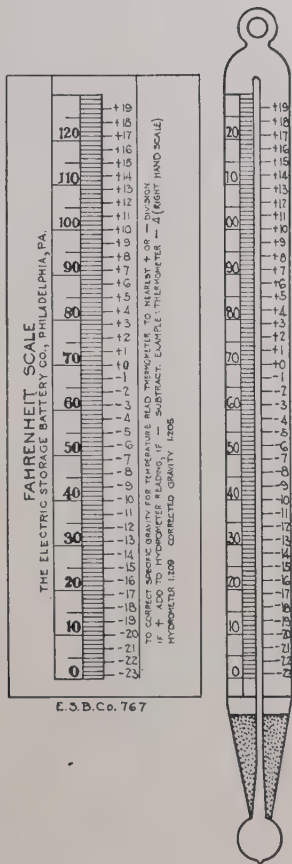


Fig. 4. Thermometer Scale, Showing Temperature Corrections

the temperature 70° is figure 0, showing that no correction is made at that temperature. Three degrees below 70° is shown minus 1, indicating that that gravity should be corrected

at that temperature by deducting one point. Three degrees above 70° is shown plus 1, which indicates that the gravity at that temperature should be corrected by adding one point to the reading, as shown by the hydrometer. A sketch of this thermometer is shown in Fig. 4.

When recording the gravity, do not make the correction for temperature, simply write down the hydrometer reading and the temperature, so that later, if it is desired to correct for temperature, it can be done.

What is Meant by "Sulphated"

During any discharge of a battery, there is being formed sulphate of lead, without which there would be no production of current. If, however, charging is neglected, the sulphate reaches a condition which tends to fill the pores of the plates and make the active material dense and hard. It is this condition which is ordinarily referred to as "sulphated."

Formation of
Sulphate

The cause of this condition is some form of abuse, such as: standing discharged for some length of time; habitual undercharging; neglecting evidence of trouble in individual cells; replacing evaporation with electrolyte, thereby restoring the specific gravity by adding acid to the cell instead of bringing it out of the plates by proper charging.

Cause of
Sulphate

The lead sulphate formed in a normal discharge of a battery is in a form in which it absorbs the charge very readily. When a battery is "sulphated," as ordinarily expressed, the sulphate is then in a condition to absorb the charge with difficulty and the ordinary charge is insufficient. Continued and persistent charging at a low rate will restore any condition of sulphate, the time being in proportion to the degree to which the condition has been allowed to extend. It is a question of time, since a higher rate will only produce gassing and high temperature, the low rate being all which the battery in this condition is capable of using.

Normal
Sulphate

Abnormal
Sulphate

Decomposi-
tion of
Sulphate

The additional length of time to restore a "sulphated" battery is illustrated by the following test: A battery was charged to a maximum and the gravity regulated to exactly 1.275 with the electrolyte just $\frac{1}{2}$ inch above the top of the plates, this height being carefully marked. The battery was discharged and then recharged to 1.275 at the normal rates. The specific gravity changed from 1.265 to 1.275 during the last hour and a half of the charge. During the following twelve weeks, the battery was discharged and recharged daily, each charge being only to 1.265, thus leaving 10 points of acid still in the plates. At the expiration of the twelve weeks, the charge was continued to determine the time required to regain the 10 points and thus restore the specific gravity to the original 1.275. Eleven hours were required instead of the hour and a half first needed. The test further illustrates why

Illustration

a battery is given an overcharge to prevent its becoming "sulphated," since, had the battery been charged daily to its maximum of 1.275 and discharged the same amount, as during the twelve weeks, nine and one-half hours of the last charge would have been saved. It is neither necessary nor desirable, however, to continue each charge to its maximum. The weekly equalizing charge is good practice.

Restoring a "Sulphated" Battery

The user is frequently too ready to conclude that his battery is "sulphated" every time the mileage obtainable is not fully up to his expectations.

If the sediment in a battery has not been allowed to reach the bottom of the plates and the level of the electrolyte has been properly maintained by replacing evaporation with pure water, the battery can be "sulphated" only because it has not been properly charged or because acid has been added to the electrolyte. An individual cell may become "sulphated" by an internal short circuit or by drying out as might be caused by failure to replace evaporation with water or failure to promptly replace a broken jar.

To determine whether a battery is "sulphated," when it is known that it does not need cleaning, it is advisable to remove it from the car, give it the ordinary equalizing charge and discharge it at the normal rate. If it gives its rated capacity, the reason for short mileage should be looked for elsewhere than in the battery.

If the rated capacity is not obtained, recharge the battery in the regular way. When the battery is considered fully charged, take and record a hydrometer reading of each cell, and the temperature of one cell. A convenient form for this purpose is shown on page 6. Charge the battery at a rate as near one-half its normal "finishing" rate as the charging apparatus will permit. If the temperature reaches 110° F., reduce the current or temporarily interrupt the charge so as not to exceed this temperature.

A battery is "sulphated" only when acid is tied up in the plates. When the specific gravity of the electrolyte has reached a maximum, it shows that there is no more sulphate to be acted upon, since during charging the electrolyte receives acid from no other source. Hydrometer readings should be recorded at regular intervals sufficiently frequently (say four to six hours apart) to determine if the specific gravity is rising or if it has reached its maximum. Continue the charge, recording the readings until there has been no further rise in any cell during a period of at least twelve hours. Maintain the level of the electrolyte at a constant height by adding water

General

Test for
"Sulphated"
Condition

If Rated
Capacity
is Obtained

If Rated
Capacity is
not Obtained

Treatment for
Restoring a
"Sulphated"
Condition

No of Plates in Jar	MV Flooded Exide										MV Exide												
	1 1/2 rib Jars					1 1/2 rib Jars					3 1/4 rib Jars												
	Charge		4 1/2 hr Discharge	AH Capacity	Element	Weight	Acid	Complete	Jar No	Width	Length	Height	Wall	Separator	Wgt	Acid	Complete	Jar No	Width	Length	Height	Wall	Separator
	Start	Rate																					
7	19	8	21	96 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	6 8	17 1/2	8	1	90	4 1/2	23 1/2	205	2 1/2	6 8	15 5/8	1	90	
9	24	10	28	126	22 1/2	4 1/2	29 1/2	57	3 1/2	7 3/4	24 1/2	9	1	90	6	29 1/2	207	3 1/2	7 3/4	16 1/2	1	90	
11	30	12	35	157 1/2	28	5 1/2	35 1/2	60	4 1/2	8 1/2	26 1/2	10	1	90	6 1/2	36	210	4 1/2	8 1/2	17 1/2	1	90	
13	35	14	42	189	33 1/2	6	42	63	5	9 1/2	28 1/2	11	1	90	7 1/2	42 1/2	213	5	9 1/2	18 1/2	1	90	
15	40	16	49	220 1/2	39 1/2	6 1/2	49	65	5 1/2	10 1/2	30 1/2	12	1	90	8 1/2	49 1/2	215	5 1/2	10 1/2	19 1/2	1	90	
17	45	18	56	252 1/2	44 1/2	7 1/2	55 1/2	68	6 1/2	11 1/2	32 1/2	13	1	90	9 1/2	55 1/2	217	6 1/2	11 1/2	20 1/2	1	90	
19	51	20	63	283 1/2	49 1/2	8 1/2	61 1/2	71	7 1/2	12 1/2	34 1/2	14	1	90	11	61 1/2	221	7 1/2	12 1/2	21 1/2	1	90	
21	56	22	70	315	55	9 1/2	68	74	8	13 1/2	36 1/2	15	1	90	12	68	224	8	13 1/2	22 1/2	1	90	
23																							
25																							

E.S. Box 517

RESTORING A "SULPHATED" BATTERY

[illegible]

MANUAL OF "Exide" BATTERIES IN ELECTRIC VEHICLES

NAME				ADDRESS				191			
TYPE OF BATTERY											
BATTERY NO.				CONSISTS OF				CELLS OF PLATES. NEW			
CAR NO.		MAKE		TYPE		MODEL		NEW			
DATE											
TIME											
AMPS.											
TEMP.											
CELL NO. GRAVITY ETC.											
1											
2											
3											
4											
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RESTORING A "SULPHATED" BATTERY

after each reading. (If water were added just before taking hydrometer readings, the water would not have time to mix with the electrolyte.) Hydrometer readings should be corrected for any considerable change in temperature in accordance with the scale shown on page 8. Should the gravity rise above 1.300 in any cell, draw off its electrolyte down to the top of the plates and put in as much water as possible without overflowing. Continue the charge, and if the gravity again goes above 1.300, it shows that acid had been added during the previous operation of the battery, and the electrolyte should be emptied out, replaced with water and the charge continued.

The treatment can be considered complete only when there has been no rise in the gravity of any cell during a period of at least twelve hours of continuous charging.

Treatment
Completed

Upon completion of the treatment, the specific gravity of the electrolyte should be adjusted to its proper value of 1.270 to 1.280, using water or 1.300 acid, as may be necessary.

In cases where one or more individual cells have become "sulphated" while the balance of the battery is in good condition, it is better to remove such cells and treat separately.

Treating
Individual
Cells

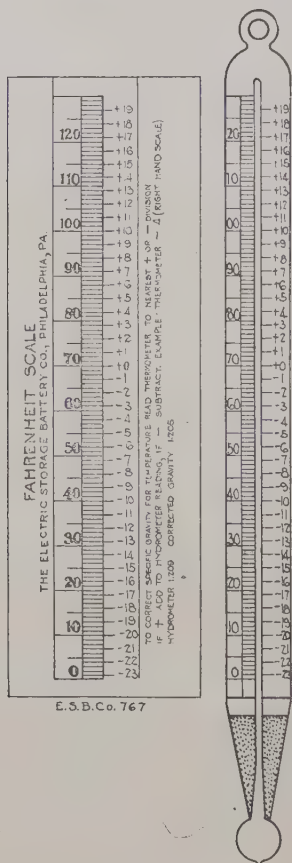
The active material of "sulphated" negative plates is generally of light color, and either hard and dense or granular and gritty and easily disintegrated. It is the negative plates which require the prolonged charge necessary to restore a "sulphated" battery.

Appearance of
"Sulphated"
Plates

"Sulphated" positives, unless physically disintegrated or badly buckled, are but little changed in general appearance and can be restored to operative conditions, although their life will not be as great as if they had not been subjected to this abuse.

"Sulphated" plates should be handled as little as possible.

By following the few simple rules of operation, all the trouble, time and expense of restoring a "sulphated" battery can always be avoided.



Thermometer Scale, Showing Temperature Corrections.

Cleaning a Battery

During the normal use of a battery the gradual wear of the plates results in a deposit (sediment) which collects in the bottom of the jar where a space is provided to hold a considerable quantity before it accumulates sufficiently to touch the bottom of the plates.

Sediment

The rate at which sediment accumulates depends largely on whether the battery is charged properly. If the battery is charged in such a way as to cause excessive gassing, the gas coming out of the pores of the positive plates tends to soften and dislodge material; this is the reason the charging current is reduced whenever the cells begin to gas freely—to avoid excessive wear. If a battery habitually receives insufficient charging the sulphate which is thus allowed to accumulate in the negative plates will eventually lose its cohesion and the surface will gradually wash away and deposit in the bottom of the jar in the form of sediment. It is neither necessary nor desirable that each charge be carried to completion, but in order to make sure that the battery does not become “sulphated” the weekly equalizing charge is given.

Rate at which
Sediment
Accumulates

If a battery has been neglected and not cleaned until after the sediment has actually reached the plates, the sediment is then deposited much more rapidly and permanent injury to the plates and decreased life results.

Since the conditions under which batteries are operated vary so widely, the best method of determining when it will be necessary to clean a battery is to remove the element from one cell after about 100 or 150 charges to determine the rate at which the sediment is accumulating. From the amount of the sediment compared with the space in the bottom of the jar, it is possible to estimate about when cleaning will be required. *Always clean a battery before the sediment reaches the bottom of the plates.* To insure this, do not count upon all the space, but allow $\frac{1}{2}$ inch in making the above estimate.

When to Clean

At the expiration of the estimated time, cut out a different cell to determine definitely if the time for cleaning has arrived.

MANUAL OF "Exide" BATTERIES IN ELECTRIC VEHICLES

"Pillar strap connectors" or "cell connectors"

When used to connect cells placed side by side is called a "side connector"

When used to connect cells placed end to end is called an "end connector"

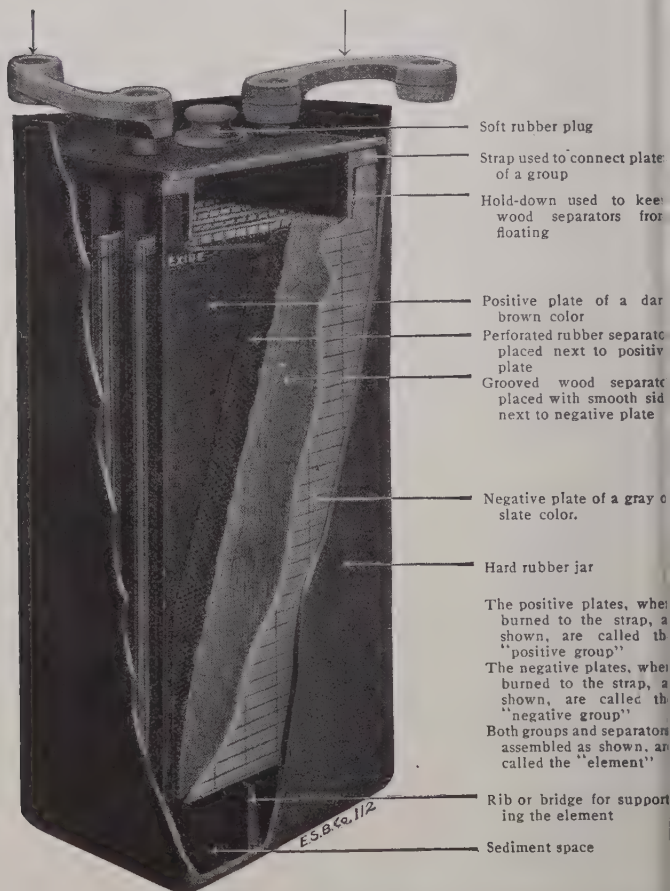


Fig. 1. One 9-MV "Exide" Cell, Showing Parts Used and Method of Assembly

CLEANING A BATTERY

The method of procedure will depend upon the condition of the battery, as follows:

1. If the battery has not been allowed to become "sulphated" and the sediment has not reached the bottom of the plates, its cleaning is a comparatively simple operation and the only preliminary treatment is to first bring it to a state of full charge.

2. If the battery is in a "sulphated" condition due to improper charging, but the sediment has not reached the bottom of the plates, it should be given the treatment, "*How to Restore a 'Sulphated' Battery*," before cleaning.

3. If the sediment has been allowed to reach the bottom of the plates because cleaning was not done soon enough, the battery will, as a matter of course, be in a "sulphated" condition by reason of the short circuits through the sediment. Such a battery must *first* be cleaned as described below and *afterward* given the treatment, "*How to Restore a 'Sulphated' Battery*." This treatment cannot be successfully given the battery in its short circuited condition.

Before starting the work of cleaning a battery, have on hand a set of new wood separators and sufficient new acid of 1.300 specific gravity from which to mix electrolyte. The amount of acid for different sizes and types of cells will be found on pages 4 and 5. The separator type and number can be found on the same page, but it is always well to specify the type of battery when ordering separators. Many of the old rubber separators can be used again, but it is well to provide about 25 per cent. of new ones. Order three or four extra rubber jars and covers. Examine the old trays to see if they are in sufficiently good condition to last the life of the plates. In ordering new trays, make a sketch (Fig. 2) showing the inside and outside length, width and height, and whether the sides are solid or slatted; also specify the size and type of handles and their position.

Make another sketch (Fig. 3) showing both the position and polarity of the cells in each tray, and indicating the position of the terminals and their polarity; that is, whether the positive is to the right or left side of the tray when facing the terminal end.

How to Proceed when :

1. Battery not "Sulphated" and Sediment not Touching Plates

2. Battery "Sulphated" and Sediment not Touching Plates

3. Sediment Touching Plates

Ordering New Material

[illegible]

General Specifications for Different Sizes and Types of Cells

2.3450617

CLEANING A BATTERY

No of Plates in Jars	MV Hycap Exide												MV Thin Exide																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
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General Specifications for Different Sizes and Types of Cells

To clean a battery, proceed as follows:

Dismantling
Battery

Remove all of the connectors from the battery. This can be done by using the regular connector puller made for

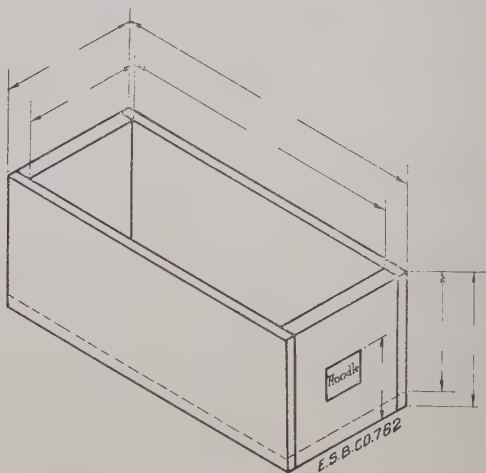


Fig. 2. Outline Sketch of Tray

the purpose, or by drilling the connectors centrally in the top of the enlarged ends. A $\frac{5}{8}$ inch wood bit is suitable (Fig. 4). After removing the connectors, remove all the covers by running a hot putty knife around the sealed edges. After remov-

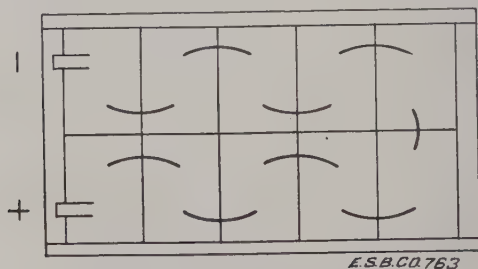


Fig. 3. Layout of Cells in Tray

CLEANING A BATTERY

ing the covers, clean off the compound and place them in hot water. This will clean the acid from the covers and also soften them. In this condition, stack the covers and put a weight on top of them, to press them out flat.

Lift all of the cells out of the trays, leaving the elements in their jars with the electrolyte. Examine the trays carefully,

Part of connector cut away
to show depth of drilling

Cell to be
removed

Method of drilling
connector

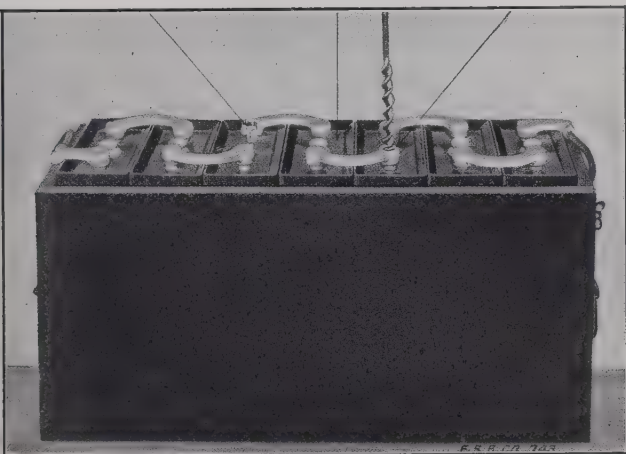


Fig. 4. Drilling off Connectors

and if they can be used again immerse them in a barrel of water in which has been dissolved about 10 pounds of bicarbonate of soda (common baking soda), to neutralize the acid in the trays. After drying, they will be ready for use.

Grip one jar firmly between the feet, grasp the posts with pliers and lift out the element (Fig. 5). Spread the plates slightly and remove the wood and rubber separators, taking care not to injure the rubber sheets (Fig. 6). Separate the positive group from the negative. If the active material of the negative plates is swollen beyond the surface of the grid,

Pressing
Negative
Plates

press it back into position before it has a chance to dry, by placing boards of suitable thickness between the plates and carefully squeezing the group between heavy boards in a vise

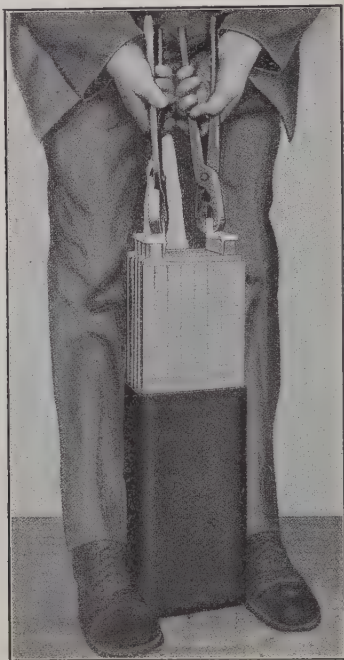


Fig. 5. Lifting Element out of Jar with Pliers

or press. Use boards of sufficient size and thickness between the plates or breakage will result (Fig. 7).

Charged negative plates when exposed to the air will in a short time become hot, and in this event should be allowed to cool before reassembling.

Positive
Plates

Remove any loose particles adhering to the positive plates by passing a smooth paddle over the surface; *but do not wash the positive plates.*

CLEANING A BATTERY

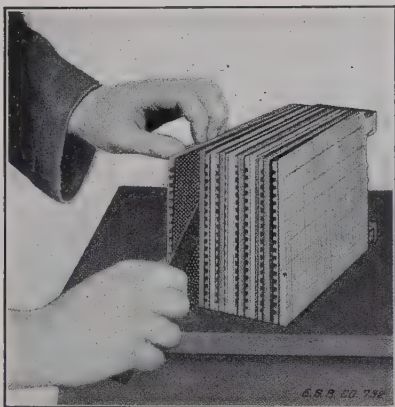


Fig. 6. Removing Old Separators from Elements

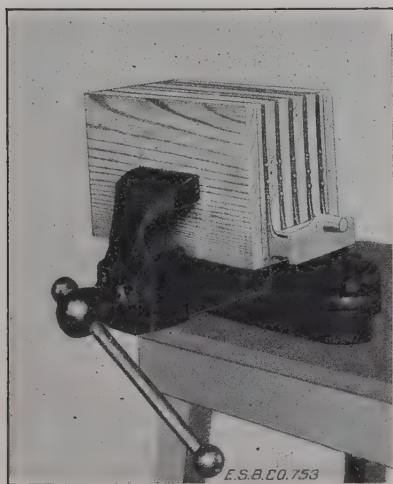
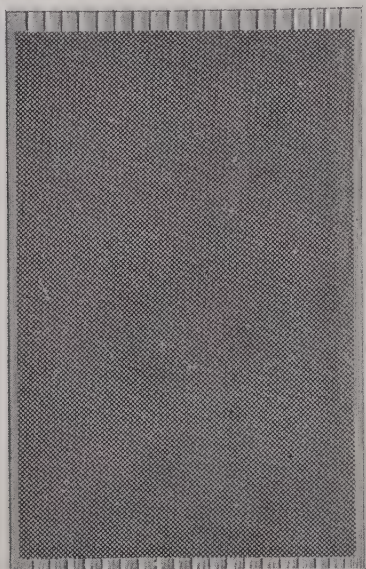


Fig. 7. Pressing Negative Group

Wash all sediment out of the jar to have it ready for re-assembling the element. Wash and save the rubber sheets; throw away the old wood separators.

Reassembling Battery

Reassemble the positive and negative groups with the plates on edge, in order to insert the separators. Place a rubber separator against the grooved side of a wood separator (Fig. 8) and insert between a positive and a negative plate



E. S. B. Co. 755

Fig. 8. Wood and Rubber Separator

near the center of the element. The rubber sheet must be against the positive and the smooth side of the wood separator against the negative plate. In like manner, insert separators in *all* the spaces, working in both directions from the center. *A separator left out means a short circuited cell.* The separators should be practically flush with the bottom of the plates to

CLEANING A BATTERY

bring their tops against the hold-down below the strap and must extend to or beyond the side edges of the plates (Fig. 9).

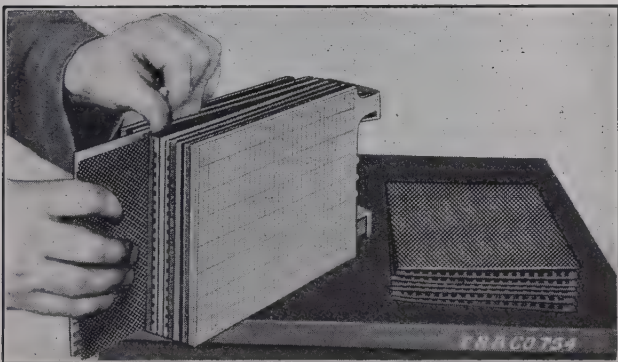


Fig. 9. Installing Separators

Grip the element near the bottom in order to keep the plates from flaring out while placing in the jar (Fig. 10).

Fill the cell to within $\frac{1}{2}$ inch of the top of the jar, using electrolyte of a specific gravity of 1.250, unless battery is in a "sulphated" condition, in which case use water instead.

After all of the cells have been reassembled, place them in trays in proper position, so that *the positive of each will be connected to the negative of the adjoining cell* and connect temporarily by pressing the old connectors in position.

Put the battery on charge (Fig. 11) at the regular "finishing" rate. After charging about fifteen minutes, note the voltage of each cell, recording these readings as shown in the first column of the form on page 19.

Charging

This is to insure that all the cells have been connected in the right direction as to polarity. If they are properly connected, each cell should read above 2 volts. Any cell below 2 volts is probably connected backwards; inspect it.

When the cells begin to gas freely and uniformly, take and record a hydrometer reading of each cell and the temperature

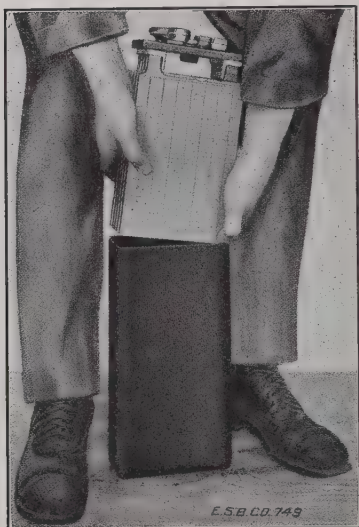


Fig. 10. Installing Element in Jar

of one cell. Reduce the current to as near one-half the normal "finishing" rate of the battery as the charging apparatus will permit.

Should the temperature at any time reach 110° F., reduce the current or temporarily interrupt the charge, so as not to exceed this temperature.

Hydrometer and temperature readings should be recorded at regular intervals, sufficiently frequently (say four to six hours apart) to determine if the specific gravity is rising or if it has reached its maximum. Continue the charge, recording the readings, until there has been no further rise in any cell during a period of at least twelve hours.

Maintain the level of the electrolyte at a constant height by adding water after each reading. (If water were added just before taking hydrometer readings, the water would not have time to mix with the electrolyte.)

CLEANING A BATTERY

Hydrometer readings should be corrected for any considerable change in temperature in accordance with the scale shown in Fig. 12.

Should the gravity rise above 1.300 in any cell, draw off its electrolyte down to the top of the plates and put in as much water as possible without overflowing. Continue the charge,

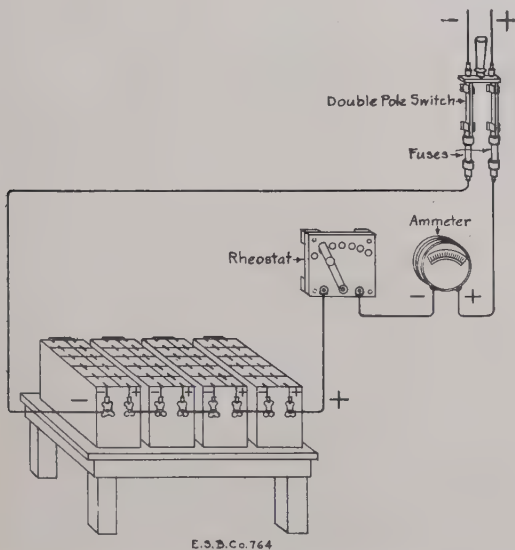


Fig. 11. Sketch of Connections for Charging Cells out of Vehicle

and if the gravity again goes above 1.300, all the electrolyte in such cell or cells should be emptied out, replaced with water and the charge continued.

The charge can be considered complete only when there has been no rise in the gravity of any cell during a period of at least twelve hours of continuous charging.

Completion
of Charge

Upon completion of the charge, the specific gravity should be adjusted to its proper value (1.270 to 1.280) using water

Adjusting
Specific
Gravity of
Electrolyte

or 1.300 acid, as may be necessary, and the electrolyte level adjusted to a uniform height of $\frac{1}{2}$ inch above the top of the plates.

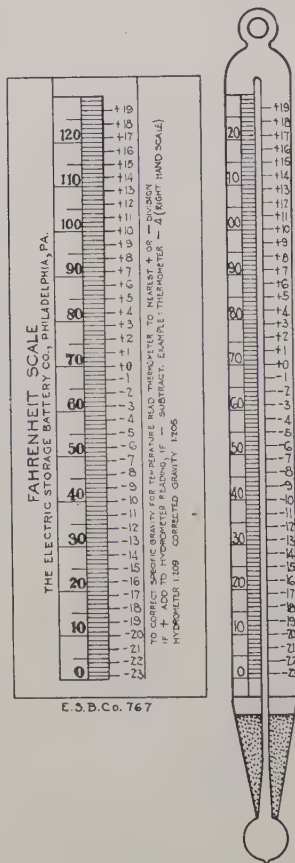
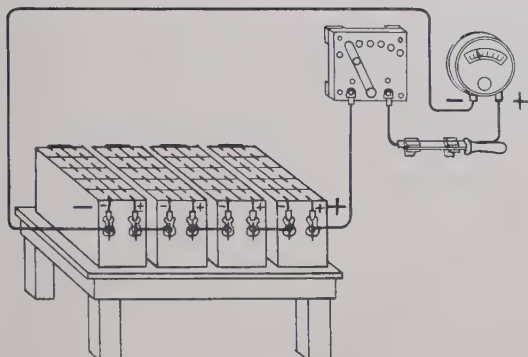


Fig. 12. Thermometer Scale, Showing Temperature Corrections.

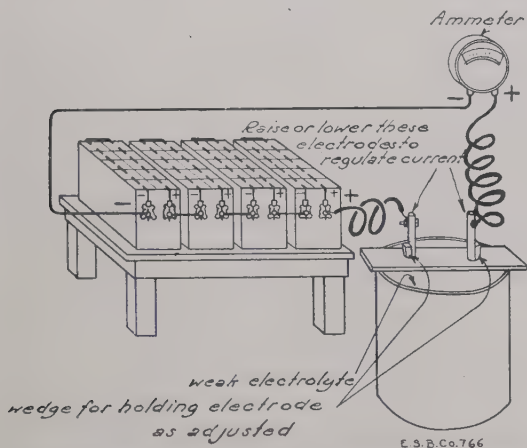
CLEANING A BATTERY

Discharge the battery (Fig. 13 or Fig. 14) at its normal discharge rate (see page 5 or page 6), to determine whether Test Discharge



E.S.B.Co.765

Fig. 13. Sketch of Connections for Discharging Cells through Regular Rheostat



E.S.B.Co.766

Fig. 14. Sketch of Connections for Discharging Cell through Water Rheostat

there are any low cells caused by defective assembly, which should be immediately corrected. Recharge the battery and remove the temporary connectors.

When the cells are arranged in their trays, as shown in the sketch made before the battery was taken apart, put the rubber covers in place, wipe the inside edges of the jars dry, and seal with the sealing compound supplied for this purpose.

Heat the sealing compound, taking care that it is not allowed to burn, and apply around the edges of the cover, smoothing down with a hot putty knife.

It is preferable to use new connectors, but if these have not been provided and if the old connectors have been removed with sufficient care, they may be used. Before replacing the connectors, see that the posts are scraped clean and smooth. In using old connectors, clean the inside of the eyes of the connectors with a knife blade. When the connectors have been placed in position, tap them down firmly over the post to insure good contact.

Before reburning the connectors, test each cell with a low reading voltmeter to make sure that the cells have been connected up in the right polarity. It is not enough to note that the voltage is right in amount, but it must be determined that the polarity is in the right direction.

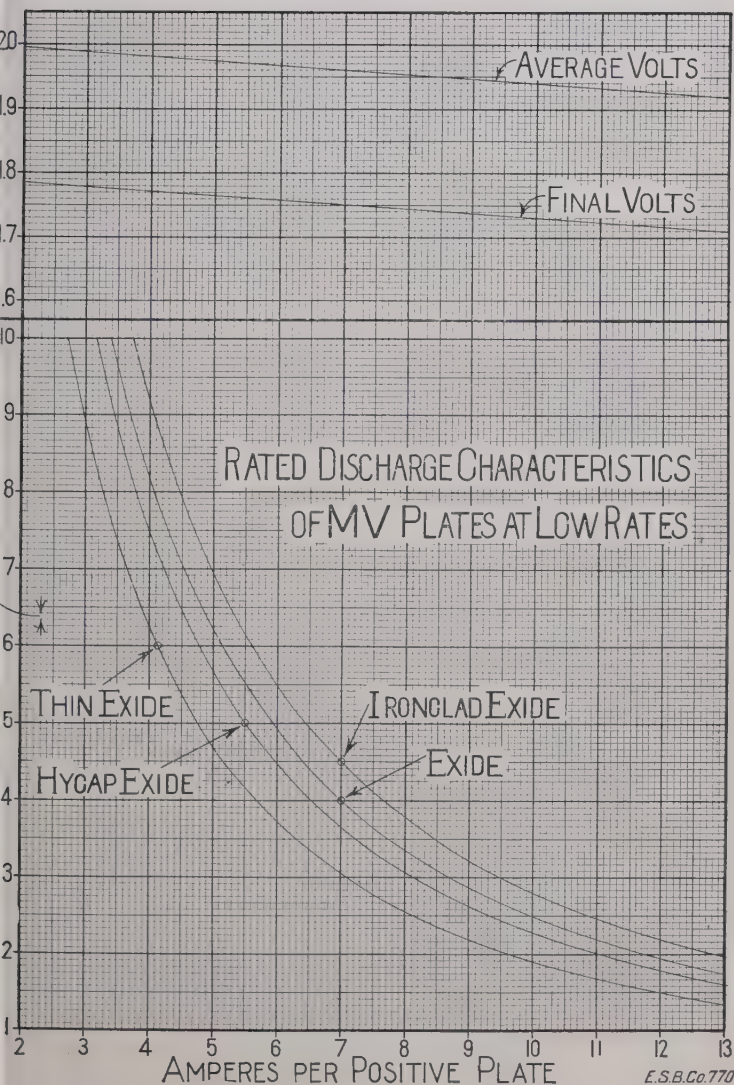
Complete the connection by melting the lead of the connector and the post at the top so that they will run together, and while the lead is still molten, melt in more until the eye of the connector is filled. This is called "lead burning," and can best be accomplished by means of a regular hydrogen flame, which should always be provided before attempting to do any work of this kind.

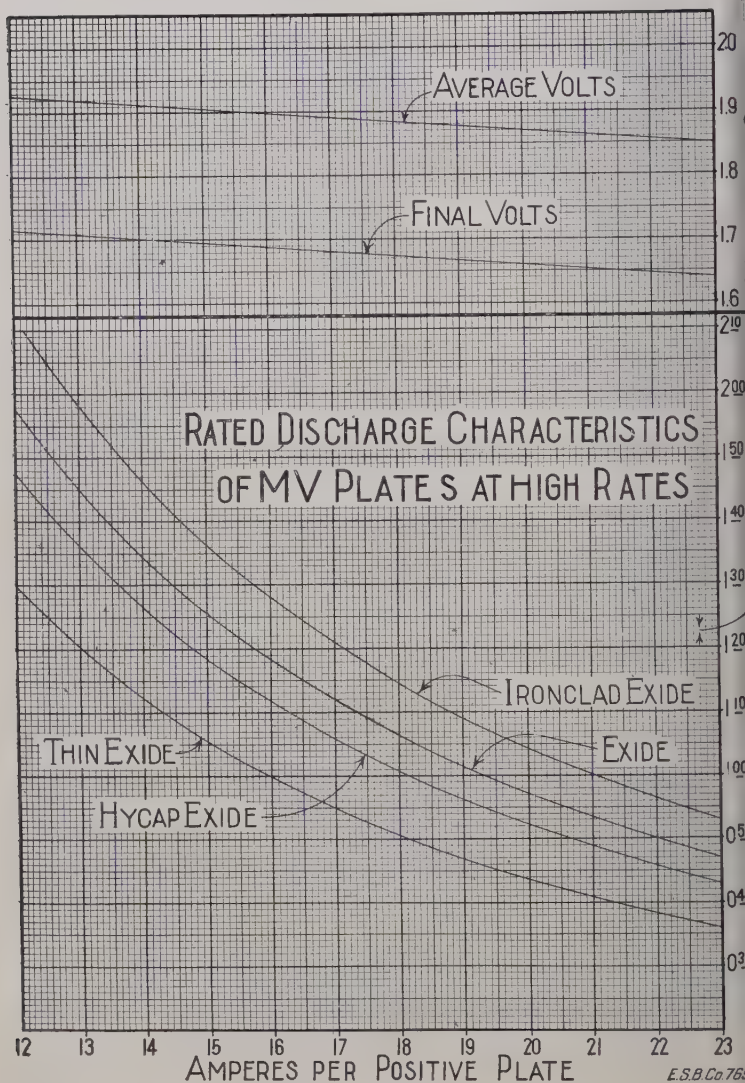
Reburning
Connectors

Never use soldering flux of any kind.

In lead burning, use only lead or alloy, similar to that of which the connectors are made. This can be procured in sticks ("burning strip") or can be made by melting down old connectors or plate straps.

After all the connectors have been burned, connect the trays together in the same way as they will be connected in the car. Charge at the regular finishing rate until all cells gas freely and uniformly immediately before installing the battery in the car, to insure that all cells are in good condition.





MANUAL OF "Exide" BATTERIES IN ELECTRIC VEHICLES

The cleaning of a battery which has been properly charged and in which the sediment has not been allowed to reach the plates is a simple operation compared with the treatment necessary to clean and restore a battery which has been neglected.

It is of the utmost importance that a battery be cleaned before the sediment reaches the bottom of the plates.

Const. Form 373 R 3-12-13-25M

DATE Jan 3-1914 "Exide" BATTERY REPORT

No. 1

No. CELLS 40 TYPE 11 mvlycap

Chicago Exide Depot

Initial CHARGE STARTED		7:30	AM Jan 4 1914	ENDED	11	AM Jan 14 1914			
CELL NUMBERS	FIRST VOLTAGE	VOL. GRV. End of Charge	VOLTAGE End of Charge	SPEC. GRV. after charging Electrolyte	CELL NUMBERS	FIRST VOLTAGE	VOL. GRV. End of Charge	VOLTAGE End of Charge	SPEC. GRV. after charging Electrolyte
1	2.06	12.85	2.59	12.78	25	2.54	12.76	2.59	12.75
2	2.06	12.84	2.61	12.78	26	2.54	12.77	2.58	12.74
3	2.06	12.82	2.60	12.77	27	2.54	12.69	2.59	12.73
4	2.07	12.77	2.58	12.74	28	2.04	12.70	2.57	12.73
5	2.11	12.71	2.60	12.74	29	2.31	12.76	2.60	12.75
6	2.16	12.69	2.61	12.73	30	2.56	12.73	2.59	12.74
7	2.16	12.70	2.59	12.73	31	2.16	12.77	2.59	12.76
8	2.14	12.73	2.59	12.75	32	2.17	12.74	2.58	12.75
9	2.16	12.76	2.58	12.74	33	2.16	12.73	2.60	12.74
10	2.16	12.73	2.60	12.74	34	2.16	12.83	2.61	12.72
11	2.16	12.77	2.59	12.76	35	2.15	12.74	2.58	12.75
12	2.18	12.74	2.59	12.75	36	2.00	12.70	2.60	12.73
13	2.10	12.80	2.58	12.77	37	2.10	12.83	2.59	12.78
14	2.20	12.83	2.57	12.78	38	2.14	12.74	2.58	12.75
15	2.26	12.76	2.60	12.75	39	2.04	12.90	2.61	12.70
16	2.16	12.73	2.59	12.74	40	2.05	12.91	2.59	12.75
17	2.16	12.70	2.61	12.73	41				
18	2.16	12.74	2.59	12.75	42				
19	2.16	12.70	2.58	12.75	43				
20	2.07	12.71	2.59	12.75	44				
21	2.07	12.65	2.60	12.73	45				
22	2.04	12.69	2.57	12.74	46				
23	2.04	12.82	2.59	12.73	47				
24	2.10	12.79	2.60	12.76	48				

Pilot cell to be inside cell near center of battery. Specific gravity readings taken every six (6) hours at proper hour in first column and to continue into following columns to end of charge.
Electrolyte in pilot cell to be kept at uniform height at one-half inch above plates in addition of distilled water only. Water to be added just after taking readings.
Any additional readings wanted can be put in blank columns. proper headings being filled in.
This sheet must be COMPLETELY FILLED OUT, nothing added or being omitted.
Discharge following this change to be recorded on back of this sheet.

BATTERY FILLED WITH 1200 Sp. Gr. 5:00
BATTERY on charge FROM 7:20 Jan 4 1914 TO 11:30 Jan 4 1914
Pilot Cell No. 16

DATE	Jan 4	5	6	7	8	9	10	11	12	13	14
Temp.		80	87	89	90	90	90	90	92	90	89
5 A.M.		5	5	5	5	5	5	5	5	5	5
Sp. Gr.		7.1	12.08	12.44	12.63	12.70	12.75	12.73	12.73	12.73	12.74
Temp.	7.3	82	87	89	90	90	90	90	90	90	90
11 A.M.		5	5	5	5	5	5	5	5	5	5
Sp. Gr.	7.1	11.65	12.18	12.50	12.64	12.71	12.73	12.73	12.73	12.73	12.74
Temp.	7.5	83	88	89	90	90	90	90	90	90	90
4 P.M.		5	5	5	5	5	5	5	5	5	5
Sp. Gr.	7.1	11.80	12.29	12.55	12.68	12.72	12.73	12.73	12.73	12.75	12.74
Temp.	7.7	86	88	89	90	90	90	90	90	85	85
11 P.M.		5	5	5	5	5	5	5	5	5	5
Sp. Gr.	7.1	11.94	12.37	12.60	12.69	12.73	12.73	12.73	12.73	12.74	12.74

REMARKS: NR: No reading. That is, gravity too low to float hydrometer. Cells purified and filled with 1275 electrolyte

ESBC. 773

Batteries in Storage

There are two general methods of putting a battery into storage, one known as "wet storage" and the other as "dry storage," the method adopted depending upon the condition of the battery and the length of time the battery is to be out of commission, thus:

General

WET STORAGE—

Any battery out of commission for less than a year, providing it will not soon require repairs necessitating dismantling.

DRY STORAGE—

(1) Any battery out of commission for longer than a year, no matter what its condition.

(2) Any battery on which repairs necessitating dismantling are, or soon will be, required.

Examine the condition of the plates and separators and also the amount of sediment in the bottom of the jars. If it is found there is very little sediment, and the plates and separators are in sufficiently good condition to give considerable additional service, the battery may be put into wet storage by giving it an equalizing charge and storing away where it will be free from dust. Replace evaporation periodically by adding distilled or other pure water to maintain the level of the electrolyte about $\frac{1}{2}$ inch above the top of the plates. At least once every four months charge the battery at one-half the normal "finishing" rate until all the cells have gassed continuously for a period of at least three hours. Any cells not gassing should be examined and the trouble remedied.

Wet Storage

When the examination has shown that the battery will soon require cleaning or repairs, it should be put into dry storage in a place free from dust, proceeding as follows:

Dry Storage

Make a sketch (Fig. 1) showing the position and polarity of the cells in each tray, and indicating the position of the terminals and their polarity; that is, whether the positive is to the right or left side of the tray when facing the terminal end.

Sketch of
Battery

Remove all of the connectors from the battery. This can be done by using the regular connector puller made for the

Dismantling
Battery

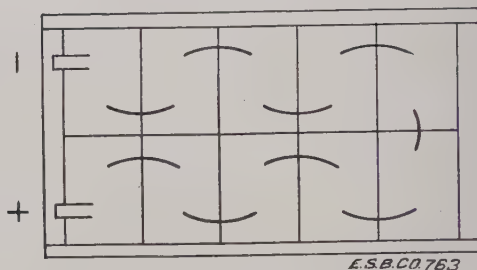


Fig. 1. Layout of Cells in Tray

purpose, or by drilling the connectors centrally in the top of the enlarged ends. A $\frac{5}{8}$ inch wood bit is suitable (Fig. 2). After removing the connectors, remove all the covers by running a hot putty knife around the sealed edges. After removing the covers, clean off the compound and place the covers in hot

Part of connector cut away
to show depth of drilling

Cell to be
removed

Method of drilling
connector

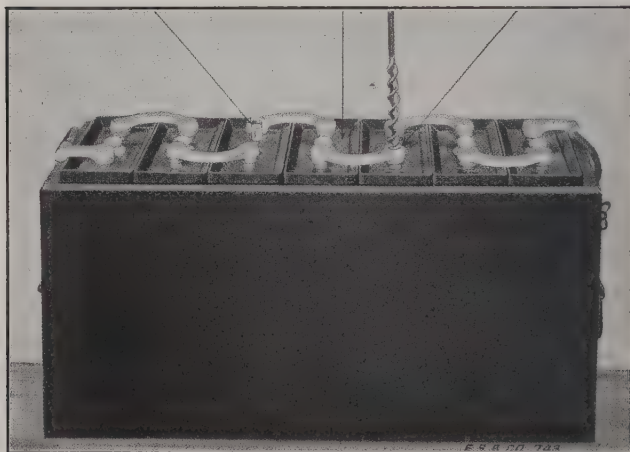


Fig. 2. Drilling off Connectors

water. This will clean the acid from the covers and also soften them. In this condition, stack the covers and put a weight on top of them, to press them out flat, and store them away.

Lift all of the cells out of the trays, leaving the elements in their jars with the electrolyte. Examine the trays carefully, and if they can be used again, immerse them in a barrel of water in which has been dissolved about 10 pounds of bicarbonate of soda (common baking soda) to neutralize the acid in the trays. After drying, store them away.

Grip one jar firmly between the feet and with pliers grasp the posts and lift out the element (Fig. 3).

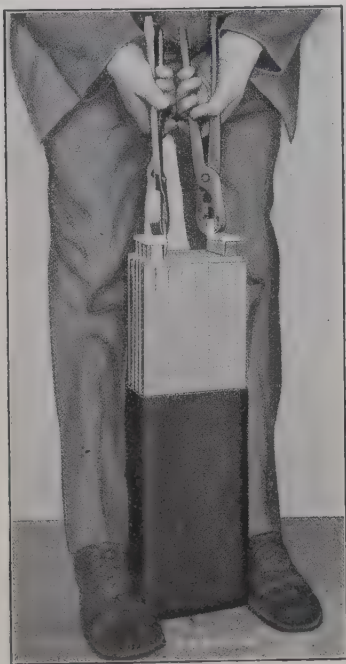


Fig. 3. Lifting Element out of Jar with Pliers

Spread the plates slightly and remove the wood and rubber separators, taking care not to injure the rubber sheets (Fig. 4).

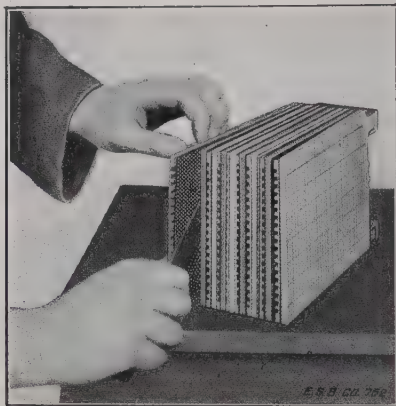


Fig. 4. Removing Old Separators from Elements

Separate the positive group from the negative. If the active material of the negative plates is swollen beyond the surface of the grid, press it back into position before it has a chance to dry, by placing boards of suitable thickness between the plates and carefully squeezing the group between heavy boards in a vise or press. Use boards of sufficient size and thickness between the plates or breakage will result (Fig. 5).

Charged negative plates when exposed to the air will in a short time become hot; they should be allowed to stand in the air until cooled.

If the positive plates show much wear, they should be scrapped; if not, remove any loose particles adhering to them by passing a smooth paddle over the surface; *but do not wash the positive plates.*

Empty the acid out of all of the jars into a glazed earthenware vessel or lead lined tank (save this acid for giving the negative plates their final treatment before storage), and wash

all sediment out of the jars. The rubber separators should be carefully washed, dried and tied in bundles.

Place the positive groups together in pairs, put into jars and store away.

Place the negative groups together in pairs, put into the remaining half of the jars, cover with acid saved for the pur-

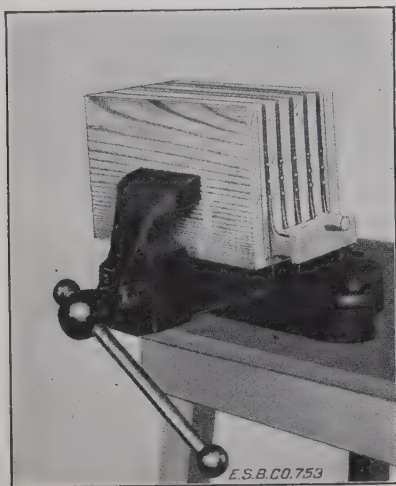


Fig. 5. Pressing Negative Group

pose and allow to stand for at least five hours. Pour off and throw away the acid and store away the jars containing the negatives.

Record the amount of material which will be required for reassembling the battery. When ordering the new material, provide three or four extra jars and covers in addition to those considered necessary for replacement, and about 25 per cent. extra rubber separators to take care of possible breakage in reassembling. Order new electrolyte of 1.200 specific gravity; the quantity required for cells of various sizes and types is shown in the tables on pages 6 and 7. Unless the old con-

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	Charge		4 1/2 hr Discharge	AH Capacity	Element	Weight	Acid	Complete	Jar No	Width	Length	Height		Wall	Acid	Complete	Jar No	Width	Length		Height	Wall	Acid	Complete	Jar No	Width	Length	Height	Wall																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
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7	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	22 1/2	81	2 1/2	68	12 1/2	8	19	8	21	34 1/2	17 1/2	3 1/2	2

General Specifications for Different Sizes and Types of Cells

BATTERIES IN STORAGE

No of Plates in Jar	MV Hycop Exide												MV Thin Exide												Lb																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
	1 1/2 rib Jars						3 rib Jars						3 1/4 rib Jars																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
	Change Rate	Start Finish	ShrDischarge	AHCapacity	Element	Weight	Jar No	Width	Length	Height	Wall	Separator	Complete	Jar No	Width	Length	Height	Wall	Separator	Start Finish	Role	ShrDischarge	AHCapacity	Element		Acid	Weight	Jar No	Width	Length	Height	Wall	Separator																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														

General Specifications for Different Sizes and Types of Cells

nectors were very carefully removed, order new ones. A new set of wood separators with 10 per cent. excess should be provided, but since wood separators must be kept wet, it is advisable not to order these too long in advance.

Advising
Owner When the work is being done for a customer, it is well to advise him at the beginning of the storage period of the amount of material required and request him to give about a month's notice in order to insure ample time to procure the new material, assemble and charge the battery.

To reassemble the battery, proceed as when making a complete renewal of the elements, which is fully described under that heading.

Complete Renewal of a Battery

The following is a tabulated list of material required for making a complete renewal:

Positive Groups	or	{ Positive plates	Material Required
		{ Positive straps	
Negative Groups	or	{ Negative plates	
		{ Negative straps	
Connectors			
Burning Strip			
Wood Separators			
Rubber Separators			
Rubber Jars			
Rubber Covers			
Rubber Plugs			
Sealing Compound			
Electrolyte			
Trays			
Handles and Terminals			

Groups—Plates: Note the number of plates in each cell and their size and type; that is, whether they are “**Exide**” or “**Hycap**,” etc. This information can usually be obtained from the name plate on each tray.

Unless facilities are available for burning the plates into groups, it is better to order groups. If the plates are ordered loose, positive and negative straps should be included in the order. In any case the following information is required:

- Size and type of plate
- Number of plates per cell
- Length of jar outside
- Width of jar outside
- Height of jar outside
- Height from top of rib to top of jar

Connectors: . In ordering connectors, give the distance between the center of the eyes (Figs. 1 and 2), noting if more than one size is required.

Terminal connectors are now all of one type, the only difference being in the size (Figs. 3, 4 and 5). Give the top diameter of the cell terminal post (see A, Fig. 11), the size of cable and length of cable for each terminal.

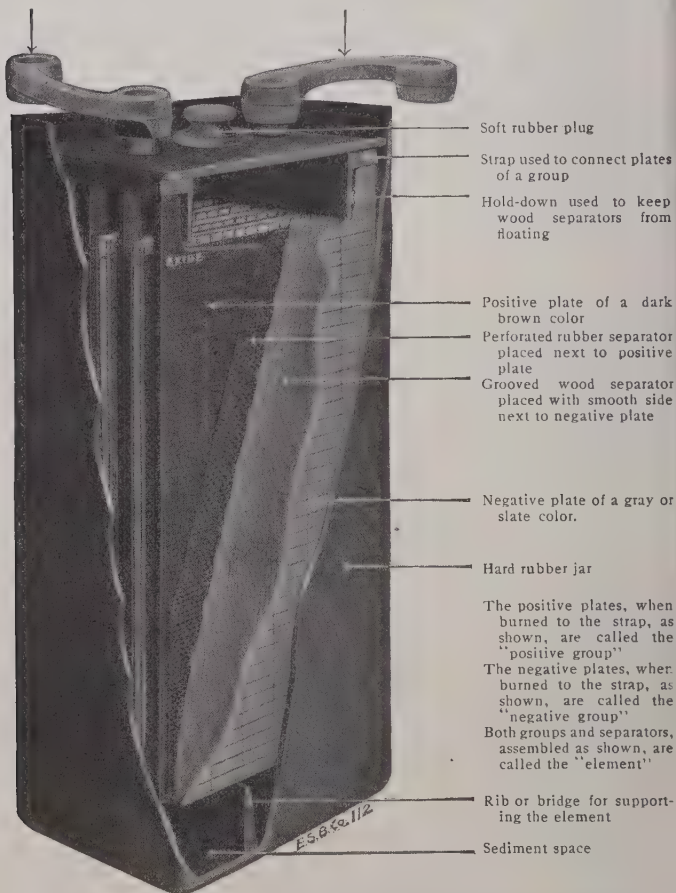
Burning Strip: Two pounds of burning strip is sufficient for burning the connectors of an ordinary battery; when loose plates are ordered, provide 1 pound additional for each fifty plates. The clippings from the plate lugs can, if desired, be melted down and cast into strips for this purpose.

MANUAL OF "Exide" BATTERIES IN ELECTRIC VEHICLES

"Pillar strap connectors" or "cell connectors"

When used to connect cells placed side by side is called a "side connector"

When used to connect cells placed end to end is called an "end connector"



One 9-MV "Exide" Cell, Showing Parts Used and Method of Assembly

Wood Separators: The separator type number can be found in the accompanying tables (see pages 5 and 6). In ordering these, it is well to provide about 10 per cent. excess over those actually required.

Rubber Separators: Most of the old rubber separators can be used again, but it is well to provide about 25 per cent. of new ones.

Rubber Jars and Covers: Order three or four extra rubber jars and covers. Give outside dimensions of jars—length, width and height; and distance from top of rib to top of jar.

Rubber Plugs: It is advisable to order a new set of plugs.

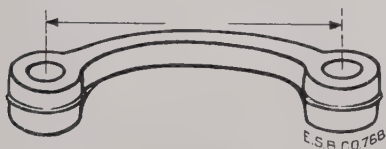


Fig. 1. Connector, Showing Centers of Eyes



Fig. 2. Flexible Connector

Sealing Compound: The average size pleasure car or light truck battery requires about $\frac{1}{8}$ pound of sealing compound per cell. The compound comes in 5, 10 and 30 pound tins.

Electrolyte: Order as much 1.200 electrolyte as will be needed; the amount required for the different types and sizes of cells can be found on pages 5 and 6. As electrolyte is usually longer in transit than other material, this should be allowed for.

Trays: In ordering new trays, make a sketch showing the inside and outside length, width and height (Fig. 9), and whether the sides are solid or slatted; also specify the size and type of handles and their position. The trays, when obtained locally, should be carefully painted with special acid resisting paint.

Handles and Terminals: In ordering handles, state size and whether they are surface or flush type. If new terminals are required, specify type (Figs. 6, 7, 8).

Upon receipt of the new material, give immediate attention to the wood separators to prevent their drying out. Wood separators *must be kept wet*.

When plates and straps are to be burned into groups, proceed as follows: Scrape the plate lugs clean and bright and



Fig. 3



Fig. 4



Fig. 5

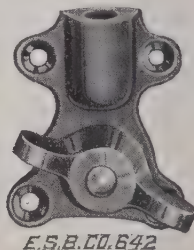


Fig. 6

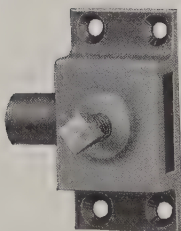


Fig. 7



E.S.B.CO. 777



Fig. 8

Fig. 3. Style H Terminal Connector

Fig. 4. Style HH Terminal Connector

Fig. 5. Style HHH Terminal Connector

Fig. 6. Wing Nut Terminal

Fig. 7. Box Type Terminal

Fig. 8. Set Screw Terminal

COMPLETE RENEWAL OF A BATTERY

MV Ironclad Exide														MV Exide																														
1 1/2 rib Jars														1 1/2 rib Jars														3 1/2 rib Jars																
No of Plates in Jar	Charge			4th Discharge	AH Capacity	Element	Weight	Acid	Complete	Jar No.	Width	Length	Height	Wall	Separator	Charge	Rate	Start	Finish	4th Discharge	AH Capacity	Element	Weight	Acid	Complete	Jar No.	Width	Length	Height	Wall	Separator	Wgt	Acid	Complete	Jar No.	Width	Length	Height	Wall	Separator				
7	19	8	21	94 1/2	17 1/2	3 1/2	27 1/2	81	2 1/2	6 1/2	12 1/2	8	1c	90	21	84	17	3 1/2	27 1/2	81	2 1/2	6 1/2	12 1/2	8	90	4 1/2	23 1/2	205	2 1/2	6 1/2	13 1/2	8	90	4 1/2	23 1/2	205	2 1/2	6 1/2	13 1/2	8	90			
9	24	10	28	126	22 1/2	4 1/2	29 1/2	57	3 1/2	7 1/2	14 1/2	10	24	112	21 1/2	21 1/2	4 1/2	28 1/2	57	3 1/2	7 1/2	15 1/2	10	126	6 1/2	36	210	4 1/2	7 1/2	15 1/2	10	126	6 1/2	36	210	4 1/2	7 1/2	15 1/2	10	126				
11	30	12	35	157 1/2	28	5 1/2	35 1/2	60	4 1/2	9 1/2	17 1/2	12	30	140	26 1/2	26 1/2	5 1/2	34 1/2	60	4 1/2	9 1/2	18 1/2	12	157 1/2	7 1/2	42 1/2	213	5	9 1/2	17 1/2	12	157 1/2	7 1/2	42 1/2	213	5	9 1/2	17 1/2	12	157 1/2				
13	35	14	42	189	33 1/2	6	42	63	5	10 1/2	20 1/2	14	35	168	31 1/2	31 1/2	6	40 1/2	63	5	10 1/2	21 1/2	14	189	8 1/2	49 1/2	215	5 1/2	11	18 1/2	12	189	8 1/2	49 1/2	215	5 1/2	11	18 1/2	12	189				
15	40	16	49	220 1/2	39 1/2	6 1/2	49	65	5 1/2	11 1/2	22 1/2	16	40	196	37	37	6 1/2	47	65	5 1/2	11 1/2	23 1/2	16	220 1/2	9 1/2	55 1/2	217	6 1/2	12	20 1/2	12	220 1/2	9 1/2	55 1/2	217	6 1/2	12	20 1/2	12	220 1/2				
17	45	18	56	252	44 1/2	7 1/2	55 1/2	68	6 1/2	12 1/2	24 1/2	18	45	224	41 1/2	41 1/2	7 1/2	53	68	6 1/2	12 1/2	25 1/2	18	252	11	61 1/2	221	7 1/2	13	22 1/2	12	252	11	61 1/2	221	7 1/2	13	22 1/2	12	252				
19	51	20	63	283 1/2	49 1/2	8 1/2	61 1/2	71	7 1/2	13 1/2	26 1/2	20	51	263	46 1/2	46 1/2	8 1/2	58 1/2	71	7 1/2	13 1/2	27 1/2	20	283 1/2	12	68	224	8	14	24 1/2	12	283 1/2	12	68	224	8	14	24 1/2	12	283 1/2				
21	56	22	70	315	55	9 1/2	68	74	8	14 1/2	28 1/2	22	56	280	51 1/2	51 1/2	9 1/2	64 1/2	74	8	14 1/2	29 1/2	22	315	12	68	224	8	14	24 1/2	12	315	12	68	224	8	14	24 1/2	12	315				
23																																												
25																																												

General Specifications for Different Sizes and Types of Cells

MV Hycap Exide														MV Thin Exide													
1 1/2 rib Jars														3 3/4 rib Jars													
No of Plates in Jar	Charge Rate		Shrn Discharge	A.H Capacity	Element	Acid		Jar No.	Width	Length	Height	Wall	Separator	Acid		Jar No.	Width	Length	Height	Wall	Separator						
	Start	Finish				Weight	Complete							Weight	Complete												
1																											
9	21	8	22	110	18 1/2	4	24 1/2	80	3	6 1/2	12 1/2	8	24	4 1/2	25 1/2	206	3	6 1/2	13 1/2	8	48						
11	24	10	27 1/2	137 1/2	23	4 1/2	29	57	3 1/2	"	"	"	40	5 1/2	30 1/2	210	3 1/2	"	"	"	"						
11	24	10	27 1/2	137 1/2	23	4 1/2	29 1/2	58	3 5/8	"	"	"	24	5 1/2	31	208	3 5/8	"	"	"	"						
13	30	12	33	165	27	5 1/2	34 1/2	60	4 1/4	"	"	"	"	6 1/2	36 1/2	210	4 1/4	"	"	"	"						
15	34	14	38 1/2	197 1/2	31	5 1/2	39 1/2	67	4 1/2	"	"	"	"	7 1/2	42	212	4 1/2	"	"	"	"						
17	38	15	44	220	36	6 1/2	45 1/2	64	5 1/2	"	"	"	"	8 1/2	47 1/2	214	5 1/2	"	"	"	"						
19	43	17	49 1/2	247 1/2	40	7	50 1/2	67	6 1/2	"	"	"	"	9 1/2	53	217	6 1/2	"	"	"	"						
21	47	19	55	275	44 1/2	7 1/2	55 1/2	69	6 3/4	"	"	"	"	10 1/2	58 1/2	219	6 3/4	"	"	"	"						
23	52	21	60 1/2	302 1/2	48 1/2	8 1/2	60 1/2	72	7 1/8	"	"	"	"	11 1/2	64	222	7 1/8	"	"	"	"						
25	56	22	66	330	52 1/2	9	65 1/2	74	8	"	"	"	"	12 1/2	68 1/2	224	8	"	"	"	"						
27																											
29	65	26	77	385	71	10 1/2	75 1/2	77	9 1/2	6 1/2	12 1/2	5 1/2	24	14 1/2	80 1/2	227	9 1/2	6 1/2	14	5 1/2	24						
31																											
33	74	30	88	440	79 1/2	11 1/2	85 1/2	82	10 1/2	6 1/2	12 1/2	5 1/2	24														

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General Specifications for Different Sizes and Types of Cells

COMPLETE RENEWAL OF A BATTERY

arrange the plates in a burning box as shown in Fig. 10. The height of this box should be $\frac{7}{8}$ of an inch less than the distance from top of the ribs of the rubber jar to the top of the jar. The burning iron, which acts as a spacer between the plates and as a support for the strap, should be made of iron $\frac{1}{8}$ inch thick, slotted to fit the plate lugs. This $\frac{1}{8}$ of an

Grouping
Plates

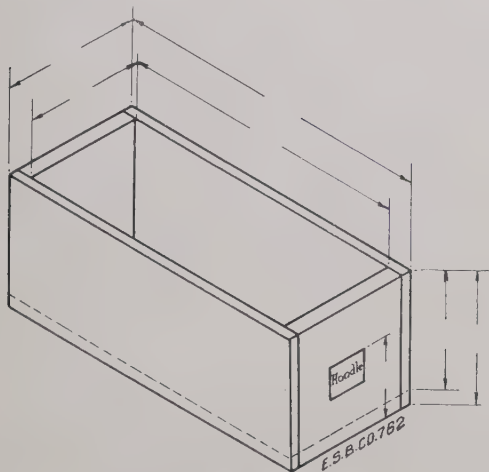


Fig. 9. Outline Sketch of Tray

inch, in addition to the height of the burning box, will give the right height for the strap, the bottom of which should be $\frac{3}{4}$ of an inch below the top of the jar.

Place the strap over the plate lugs to rest on the burning iron. The plate lugs should be trimmed about flush with the top of the strap. After burning, cut off the projecting ends of the negative straps so that the elements may enter the jars (Fig. 11). It is not necessary to clip off the projecting ends of the positive straps.

The old battery can now be dismantled, first making sketch, showing both position and polarity of the cells in each tray and indicating the position of the tray terminals and

Dismantling
Old Battery

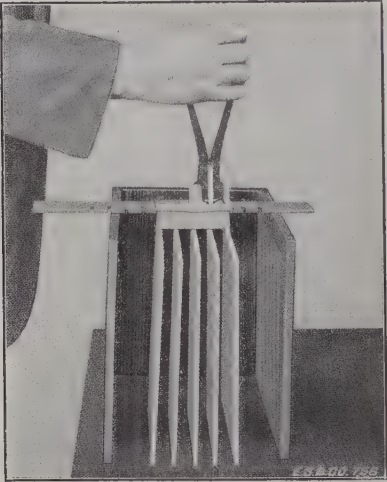


Fig. 10. Assembling Group in Burning Box

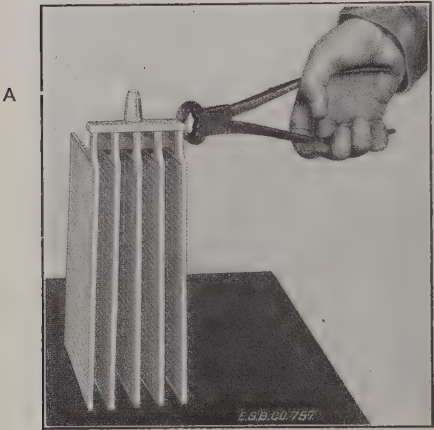


Fig. 11. Clipping off End of Negative Strap

COMPLETE RENEWAL OF A BATTERY

their polarity; that is, whether the positive is to the right or left side of the tray when facing the terminal end (Fig. 12).

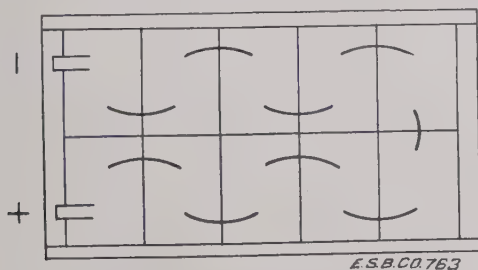


Fig. 12. Layout of Cells in Tray

To dismantle a battery, proceed as follows:

Remove all of the connectors from the battery. This can be done by using the regular connector puller made for the purpose or by drilling the connectors centrally in the top of the enlarged ends. A $\frac{5}{8}$ inch wood bit is suitable (Fig. 13).

Part of connector cut away
to show depth of drilling

Cell to be
removed

Method of drilling
connector

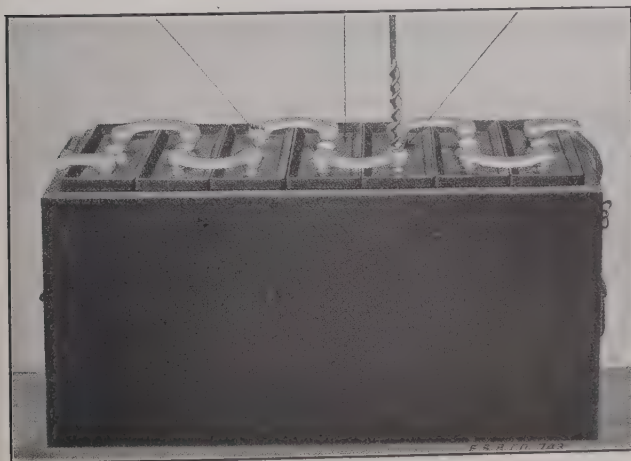


Fig. 13. Drilling off Connectors

After removing the connectors, remove all the covers by running a hot putty knife around the sealed edges. After removing the covers, clean off the compound and place them in hot water. This will clean the acid from the covers and also soften them. In this condition, stack the covers and put a weight on top of them, to press them out flat.

Lift all of the cells out of the trays. When making a complete renewal, the old trays are seldom worth saving; but if they are to be used again, immerse them in a barrel of water in which has been dissolved about 10 pounds of bicarbonate of soda (common baking soda), to neutralize the acid in the trays. After drying, they will be ready for use.

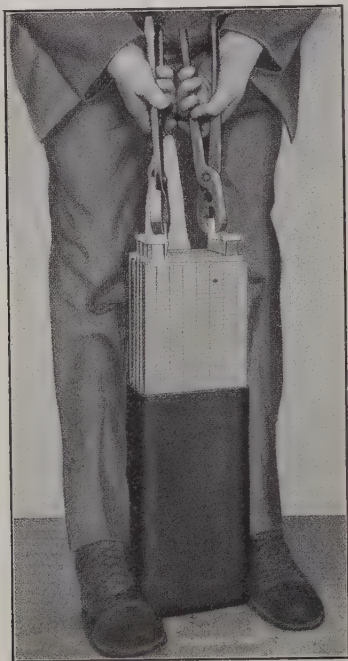


Fig. 14. Lifting Element out of Jar with Pliers

COMPLETE RENEWAL OF A BATTERY

Grip one jar firmly between the feet, grasp the posts with pliers and lift out the element (Fig. 14).

Spread the plates slightly and remove the wood and rubber separators, taking care not to injure the rubber sheets (Fig. 15).

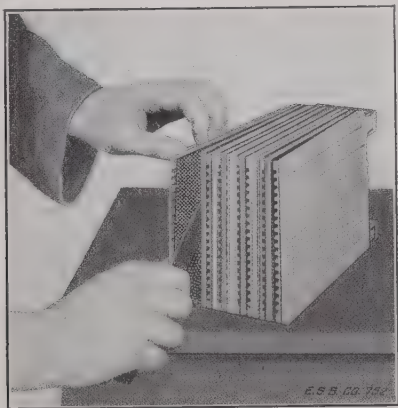


Fig. 15. Removing Old Separators from Elements

Throw away the old wood separators and scrap the old plates. Wash all sediment out of the jars to have them ready for assembling the new elements.

Assemble the new positive and negative groups with the plates on edge in order to insert the separators. Place a rubber separator against the grooved side of a wood separator (Fig. 16) and insert between a positive and a negative plate near the center of the element. The rubber sheet must be against the positive and the smooth side of the wood separator against the negative plate (Fig. 17). In like manner, insert separators in *all* the spaces, working in both directions from the center. *A separator left out means a short circuited cell.* The separators should be practically flush with the bottom of the plates to bring their tops against the hold-down below the strap, and must extend to or beyond the side

Assembling
New Elements

MANUAL OF "Exide" BATTERIES IN ELECTRIC VEHICLES

of the accompanying form (Fig. 19). This is to insure that all the cells have been connected in the right direction as to polarity. If they are properly connected, each cell should read above 2 volts. Any cell below 2 volts is probably connected backward; inspect it.

Reduce the current to as near one-half the normal "finishing" rate of the battery as the charging apparatus will per-

Const. Form 373 R 3-12-13-25M

DATE Jan 3-1914 "Exide" BATTERY REPORT No. 1
Chicago Exide Depot
No. CELLS 40 TYPE 11 MV
Initial CHARGE STARTED 7:30 A.M. Jan 4 1914 ENDED 11 A.M. Jan 4 1914

CELL NUM-BERS	FIRST VOLTAGE	SPEC. GRAV. End of Charge	VOLTAGE End of Charge	SPEC. GRAV. after evening Electrolyte	CELL NUM-BERS	FIRST VOLTAGE	SPEC. GRAV. End of Charge	VOLTAGE End of Charge	SPEC. GRAV. after evening Electrolyte	
1	2.66		1285	2.59	1278	25	2.24	1276	2.59	1275
2	2.66		1284	2.61	1278	26	2.24	1277	2.58	1274
3	2.66		1282	2.60	1277	27	2.04	1269	2.57	1273
4	2.01		1279	2.58	1276	28	2.04	1270	2.60	1275
5	2.11		1277	2.60	1277	29	2.11	1276	2.60	1275
6	2.16		1269	2.67	1273	30	2.11	1273	2.59	1274
7	2.14		1270	2.59	1273	31	2.16	1277	2.59	1275
8	2.14		1273	2.58	1275	32	2.17	1274	2.58	1275
9	2.16		1276	2.58	1274	33	2.16	1273	2.60	1274
10	2.16		1273	2.60	1274	34	2.16	1273	2.61	1275
11	2.16		1277	2.57	1275	35	2.15	1270	2.60	1273
12	2.18		1270	2.58	1277	36	2.10	1273	2.59	1278
13	2.10		1283	2.57	1275	37	2.10	1274	2.58	1275
14	2.22		1276	2.60	1275	38	2.14	1274	2.58	1278
15	2.16		1273	2.59	1274	39	2.05	1270	2.61	1278
16	2.16		1280	2.59	1275	40	2.05	1271	2.59	1275
17	2.16		1274	2.59	1275					
18	2.16		1270	2.58	1275					
19	2.16		1271	2.59	1275					
20	2.16		1271	2.59	1275					
21	2.04		1285	2.60	1278					
22	2.04		1283	2.57	1274					
23	2.10		1282	2.59	1274					
24	2.10		1274	2.58	1276					

Pilot cell to be inside cell near center of battery. Specific gravity readings taken every six (6) hours at proper time in first column and to continue into following columns to end of charge.
Electrolyte in pilot cell to be kept at uniform height at one-half inch above plates for addition of distilled water only. Water to be added just after taking readings.
Any additional readings wanted can be put in blank columns; proper headings being filled in.
This sheet must be COMPLETED BY PILOT CELL UNIT, unless it is kept for being "united".
Recharge following this charge to be recorded on back of this sheet.

BATTERY FILLED WITH 1200 Sp. Gr. 5:00 Jan 3 1914
BATTERY on charge FROM 7:20 A.M. Jan 4 1914 TO 11:30 A.M. Jan 4 1914
Pilot Cell No. 16

DATE	Jan	4	5	6	7	8	9	10	11	12	13	14
Temp.			80	87	89	90	90	90	90	90	90	89
Rate			7.1	12.08	12.44	12.63	12.70	12.73	12.73	12.73	12.73	12.74
Sp. Gr.			7.1	1.165	1.180	1.250	1.266	1.271	1.273	1.273	1.273	1.274
Temp.	7.3	82	87	89	90	90	90	90	90	90	90	90
Rate	7.1	11.65	12.18	12.50	12.66	12.71	12.73	12.73	12.73	12.73	12.73	12.74
Sp. Gr.	7.1	1.165	1.180	1.250	1.266	1.271	1.273	1.273	1.273	1.273	1.273	1.274
Temp.	7.5	83	88	89	90	90	90	90	90	90	90	90
Rate	7.5	11.80	12.29	12.55	12.68	12.72	12.73	12.73	12.73	12.73	12.73	12.74
Sp. Gr.	7.5	1.180	1.229	1.255	1.268	1.272	1.273	1.273	1.273	1.273	1.273	1.274
Temp.	7.7	86	88	89	90	90	90	90	90	90	90	90
Rate	7.7	11.94	12.37	12.60	12.69	12.73	12.73	12.73	12.73	12.73	12.73	12.74
Sp. Gr.	7.7	1.194	1.237	1.260	1.269	1.273	1.273	1.273	1.273	1.273	1.273	1.274

REMARKS: NR. No reading. That is, gravity too low to float hydrometer. Cells completed and filled with electrolyte

ESB Co. 775

Fig. 19. Specimen Form for Charging Record. Form 373 R

mit. Select one cell near the center of the battery, which will be the "pilot cell" throughout the entire charge. Record readings of time and current, and the specific gravity and temperature of the pilot cell, as indicated in the form, Fig. 19, at intervals of from six to twelve hours. Should the temperature at any time reach 110° F., reduce the current or temporarily interrupt the charge so as not to exceed this temperature.

Maintain the level of the electrolyte by adding water as necessary. Never add water just before taking hydrometer readings, because it would not have time to mix with the electrolyte. Hydrometer readings should be corrected for any considerable change in temperature in accordance with the scale shown in Fig. 20.

When the gravity of the pilot cell has shown no further rise during a period of twenty-four hours, record hydrometer readings of each cell in the columns marked "Spec. Grav." (Fig. 19). In recording readings, start at the positive terminal cell of the battery as cell No. 1, and follow the direction of the electric circuit. Individual cell readings should be recorded at intervals of about twelve hours *to insure that each reaches a maximum*. Bear in mind that the object of the initial charge is to completely remove all acid combined in the plates.

Do not stop the initial charge simply because a gravity of 1.270 or 1.280 may have been reached, because this may not be the maximum. Continue to charge as long as the gravity continues to rise. The charge can be considered complete only when there has been *no rise in the gravity of any cell during a period of twenty-four hours of continuous charging*.

In case the gravity rises above 1.290 in any cell, draw off its electrolyte down to the top of the plates and replace with water, saving this electrolyte for adjusting the specific gravity of the cells as follows:

Upon completion of the charge, adjust the specific gravity to its proper value (1.270 to 1.280), using water or electrolyte as may be required, and bring the level of the electrolyte to a uniform height of ½ inch above the top of the plates. Some variation in the specific gravity among different cells is

Completion of
"Initial
Charge"

Adjusting
Specific
Gravity
of Electrolyte

MANUAL OF "Exide" BATTERIES IN ELECTRIC VEHICLES

of the accompanying form (Fig. 19). This is to insure that all the cells have been connected in the right direction as to polarity. If they are properly connected, each cell should read above 2 volts. Any cell below 2 volts is probably connected backward; inspect it.

Reduce the current to as near one-half the normal "finishing" rate of the battery as the charging apparatus will per-

Cust. Form 113 B-12-13-1934

DATE Jan 3-1914 "Exide" BATTERY REPORT No. 1

No. CELLS 40 TYPE 11 mv type Chicago Exide Depot

Initial CHARGE STARTED 7:30 Jan 4 1914 ENDED 11 Jan 4 1914

CELL NUM-BERS	FIRST VOLTAGE	SPEC. GRAV. End of Charge	VOLTAGE End of Charge	SPEC. GRAV. after moving Electrolyte	CELL NUM-BERS	FIRST VOLTAGE	SPEC. GRAV. End of Charge	VOLTAGE End of Charge	SPEC. GRAV. after moving Electrolyte
1	2.06	1.285	2.59	1.278	25	2.04	1.276	2.59	1.275
2	2.06	1.284	2.61	1.278	26	2.04	1.271	2.58	1.274
3	2.00	1.282	2.60	1.277	27	2.04	1.269	2.59	1.273
4	2.01	1.277	2.58	1.276	28	2.04	1.270	2.57	1.273
5	2.11	1.271	2.60	1.274	29	2.01	1.266	2.60	1.273
6	2.16	1.269	2.61	1.273	30	2.01	1.273	2.59	1.274
7	2.16	1.270	2.59	1.273	31	2.16	1.277	2.59	1.276
8	2.14	1.273	2.58	1.275	32	2.17	1.274	2.58	1.275
9	2.14	1.276	2.58	1.274	33	2.16	1.273	2.60	1.274
10	2.16	1.273	2.60	1.274	34	2.16	1.273	2.61	1.273
11	2.16	1.277	2.57	1.276	35	2.15	1.274	2.59	1.273
12	2.18	1.274	2.59	1.275	36	2.10	1.273	2.59	1.273
13	2.10	1.270	2.58	1.277	37	2.00	1.270	2.60	1.273
14	2.20	1.273	2.59	1.275	38	2.14	1.274	2.58	1.273
15	2.26	1.276	2.60	1.275	39	2.04	1.270	2.61	1.270
16	2.16	1.273	2.59	1.274	40	2.05	1.271	2.59	1.270
17	2.16	1.270	2.61	1.272					
18	2.16	1.274	2.59	1.273					
19	2.14	1.270	2.58	1.270					
20	2.00	1.271	2.59	1.270					
21	2.01	1.285	2.60	1.278					
22	2.04	1.283	2.57	1.278					
23	2.04	1.282	2.59	1.277					
24	2.10	1.279	2.60	1.276					

Pilot cell to be inside cell near center of battery. Specific gravity readings taken every six (6) hours at proper hour in first column and to continue into following columns in end of charge.

Electrolyte in pilot cell to be kept at uniform height at one-half inch above plates by addition of distilled water only. Water to be added just after taking readings.

Any additional readings wanted can be put in blank columns; proper headings being filled in.

This sheet must be COMPLETELY FILLED OUT, nothing asked for being omitted.

Discharge following this charge to be recorded on back of this sheet.

BATTERY FILLED WITH 1200 Sp. Gr. 5.00 Jan 3 1914

BATTERY on charge FROM 7:20 Jan 4 1914 TO 11:30 Jan 4 1914

Pilot Cell No. 16

DATE	Jan	4	5	6	7	8	9	10	11	12	13	14
Temp.			80	87	89	90	90	90	90	90	90	90
Rate			5	5	5	5	5	5	5	5	5	5
Sp. Gr.			1.171	1.208	1.244	1.263	1.270	1.273	1.273	1.273	1.273	1.274
Temp.		73	82	87	89	90	90	90	90	90	90	90
Rate		5	5	5	5	5	5	5	5	5	5	5
Sp. Gr.		1.171	1.165	1.218	1.250	1.266	1.271	1.273	1.273	1.273	1.273	1.274
Temp.		75	83	88	89	90	90	90	90	90	90	90
Rate		5	5	5	5	5	5	5	5	5	5	5
Sp. Gr.		1.171	1.180	1.228	1.255	1.268	1.272	1.273	1.273	1.273	1.273	1.274
Temp.		77	86	88	89	90	90	90	90	90	90	90
Rate		5	5	5	5	5	5	5	5	5	5	5
Sp. Gr.		1.171	1.194	1.237	1.260	1.269	1.273	1.273	1.273	1.273	1.274	1.274

REMARKS:

NR: No reading. That is, gravity too low to float hydrometer. Cells completed and filled with electrolyte

ESB Co. 773

Fig. 19. Specimen Form for Charging Record. Form 373 R

COMPLETE RENEWAL OF A BATTERY

mit. Select one cell near the center of the battery, which will be the "pilot cell" throughout the entire charge. Record readings of time and current, and the specific gravity and temperature of the pilot cell, as indicated in the form, Fig. 19, at intervals of from six to twelve hours. Should the temperature at any time reach 110° F., reduce the current or temporarily interrupt the charge so as not to exceed this temperature.

Maintain the level of the electrolyte by adding water as necessary. Never add water just before taking hydrometer readings, because it would not have time to mix with the electrolyte. Hydrometer readings should be corrected for any considerable change in temperature in accordance with the scale shown in Fig. 20.

When the gravity of the pilot cell has shown no further rise during a period of twenty-four hours, record hydrometer readings of each cell in the columns marked "Spec. Grav." (Fig. 19). In recording readings, start at the positive terminal cell of the battery as cell No. 1, and follow the direction of the electric circuit. Individual cell readings should be recorded at intervals of about twelve hours *to insure that each reaches a maximum*. Bear in mind that the object of the initial charge is to completely remove all acid combined in the plates.

Do not stop the initial charge simply because a gravity of 1.270 or 1.280 may have been reached, because this may not be the maximum. Continue to charge as long as the gravity continues to rise. The charge can be considered complete only when there has been *no rise in the gravity of any cell during a period of twenty-four hours of continuous charging*.

In case the gravity rises above 1.290 in any cell, draw off its electrolyte down to the top of the plates and replace with water, saving this electrolyte for adjusting the specific gravity of the cells as follows:

Upon completion of the charge, adjust the specific gravity to its proper value (1.270 to 1.280), using water or electrolyte as may be required, and bring the level of the electrolyte to a uniform height of $\frac{1}{2}$ inch above the top of the plates. Some variation in the specific gravity among different cells is

Completion of
"Initial
Charge"

Adjusting
Specific
Gravity
of Electrolyte

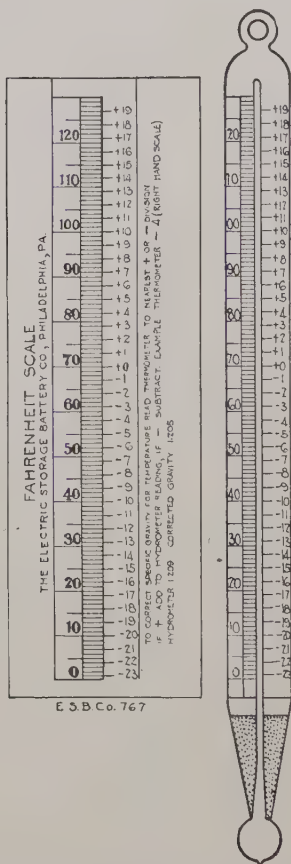
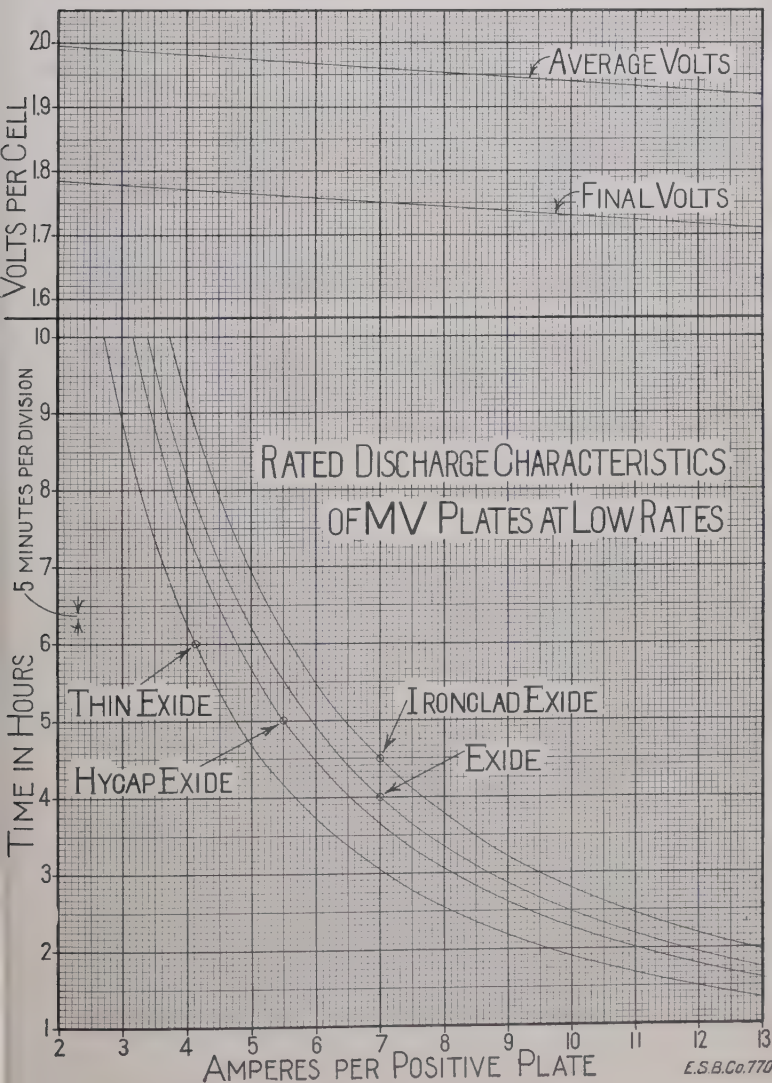
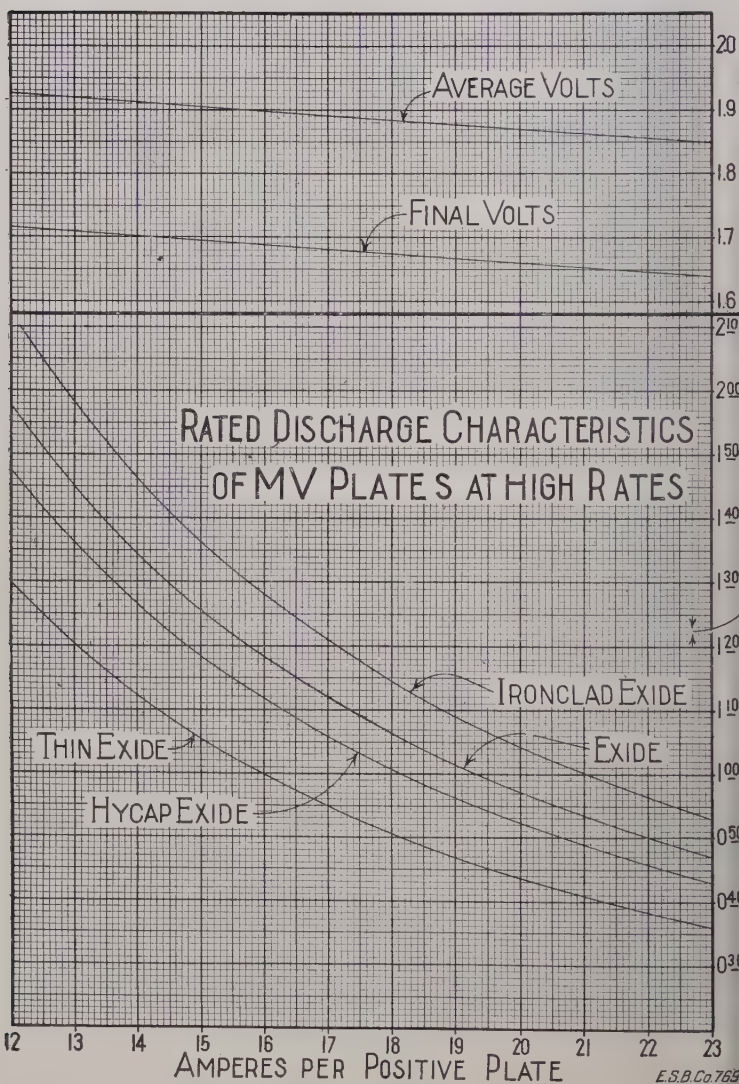


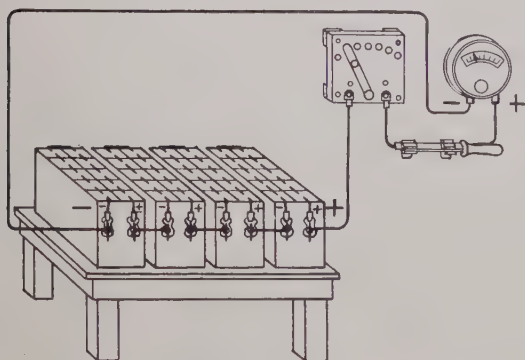
Fig. 20. Thermometer Scale, Showing Temperature Corrections





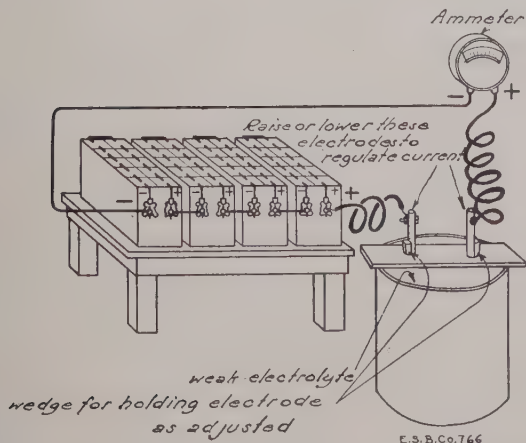
COMPLETE RENEWAL OF A BATTERY

to be expected, since the amount of water in the separators difference in level when filled, etc., affect this.



E.S.B.Co.765

Sketch of Connections for Discharging Cells through Regular Rheostat



E.S.B.Co.766

Sketch of Connections for Discharging Cells through Water Rheostat

Test
Discharge

Discharge the battery, preferably at its normal discharge rate (see pages 5 and 6), to find any possible low cells, caused by defective assembly, which should be immediately corrected, and to determine the capacity. A convenient form for keeping the discharge record is shown on page 21.

Capacity does not necessarily indicate the completeness or incompleteness of the initial charge. The only sure indication is maximum specific gravity reached in every cell.

Should a second test discharge be taken, the capacity will be somewhat less than that of the first; but after several discharges, the battery will not only recover but will exceed its first capacity.

The foregoing outline of procedure is based upon the assumption that the initial charge is continuous, since this will require the shortest time. It is especially desirable that at least the first twenty-four hours of the charge be given without interruption even if the entire charge cannot be made continuous. Where there are interruptions, the twenty-four hours of maximum gravity must be actual charging time and must not include any idle time.

The accuracy of the ammeter should be checked at the currents used.

Warning

A battery which has not received sufficient initial charge cannot be expected to give satisfactory service and life. Therefore, in case of any doubt, prolong the charge rather than run the chance of stopping it too soon.

As a further precaution, it is advisable to see that the first few charges after the battery goes into service are somewhat prolonged.

COMPLETE RENEWAL OF A BATTERY

DATE Jan 14-1914 DISCHARGE No. 1
 RATE 27.5 AMPERES FOR 5:25 HOURS. TEMPERATURE BEGINNING OF DISCHARGE 90 TEMPERATURE END OF DISCHARGE 88
1st DISCHARGE STARTED 11:30 A.M. Jan 14 1914 ENDED 4:55 P.M. Jan 14 1914

CELL NUM- BERS	VOLTAGE End of 4:30 hrs.	VOLTAGE End of 4:52 hrs.	VOLTAGE End of 5:10 hrs.	VOLTAGE End of 5:25 hrs.
1	1.89	1.85	1.80	1.72
2	1.90	1.87	1.82	1.74
3	1.90	1.88	1.83	1.75
4	1.90	1.86	1.80	1.70
5	1.90	1.87	1.82	1.73
6	1.90	1.88	1.84	1.74
7	1.90	1.89	1.82	1.73
8	1.90	1.89	1.84	1.75
9	1.91	1.89	1.86	1.77
10	1.90	1.88	1.84	1.71
11	1.90	1.87	1.84	1.71
12	1.91	1.88	1.82	1.70
13	1.90	1.89	1.85	1.75
14	1.90	1.89	1.84	1.76
15	1.90	1.87	1.83	1.72
16	1.90	1.86	1.82	1.71
17	1.90	1.86	1.82	1.70
18	1.90	1.87	1.82	1.72
19	1.90	1.86	1.84	1.76
20	1.90	1.86	1.80	1.70
21	1.90	1.86	1.82	1.74
22	1.90	1.87	1.82	1.74
23	1.91	1.89	1.82	1.74
24	1.90	1.89	1.84	1.77
25	1.90	1.89	1.82	1.71
26	1.90	1.88	1.84	1.75
27	1.91	1.88	1.82	1.71
28	1.90	1.87	1.82	1.77
29	1.90	1.88	1.82	1.74
30	1.90	1.89	1.84	1.77
31	1.91	1.87	1.83	1.75
32	1.90	1.87	1.82	1.74
33	1.90	1.88	1.82	1.76
34	1.90	1.87	1.82	1.75
35	1.90	1.87	1.84	1.75
36	1.90	1.86	1.82	1.73
37	1.89	1.86	1.82	1.73
38	1.91	1.86	1.80	1.67
39	1.91	1.88	1.82	1.72
40	1.84	1.88	1.86	1.77
41				
42				
43				
44				
45				
46				
47				
48				

First discharge voltage reading to be taken for "match" cells at end of three and one-half (3½) hours for "Hi-cap-Etite" cells at four and one-half (4½) hours; for "Chine-Etite" at five and one-half (5½) hours; and second reading twenty (20) minutes after first reading, third reading twenty (20) minutes after second reading. Final reading when several cells reach 1.1 volts, noting total elapsed time.

Additional readings may be recorded in blank columns, proper headings being filled in.

If this is final discharge before shipment, make a note in this effect in the space provided for remarks.

REMARKS:

Specimen Form for Discharge Record. Form 373 R

Replacing Evaporation

The electrolyte in a cell consists of a mixture of sulphuric acid and water. Sulphuric acid does not evaporate, water does. When the level of the electrolyte in a cell becomes low, it is due, under normal conditions, to the evaporation of water, which should be replaced with water only.

There being no loss of acid, it is never necessary, during normal service, to add any acid to a battery.

Of course, if a battery is upset and acid spilled or if a jar is broken and acid leaks out, it should be replaced. In the event of any cells having been flooded, by wash water or other cause, provision should immediately be made to prevent a recurrence. *Unless acid is actually known to be lost out of a cell, none should ever be added during the entire life of a battery.* The amount of acid lost in spray is immeasurably small and should be neglected.

Use only distilled or other water of approved purity for replacing evaporation. Most natural waters contain impurities, some of which are chemically injurious to batteries, while others are not. Water for regular use in batteries should always be submitted to the battery manufacturer for approval.

It is necessary that the plates and separators be covered with electrolyte at all times. When adding water, cover the plates about $\frac{1}{2}$ inch. Do not put in more than this amount, as cells which are filled too full tend to slop over while the car is being run and also while charging, since the gassing raises the level of the electrolyte.

Replace evaporation every five to fifteen days, depending upon the conditions of service. The best time for adding water is just before a charge.

A good method of replacing evaporation is to use a syringe, a standard hydrometer syringe, with the hydrometer removed, being suitable.

The electrolyte in a fully charged cell of the vehicle type should have a specific gravity of 1.270 to 1.280, although the battery will continue to give good service between the limits of 1.250 and 1.300. If the specific gravity of the electrolyte in any cell is higher than 1.300, it should be reduced; if lower than 1.250, the cause should be promptly investigated and corrected.

General

Why Use
Water Only

Never Add
Acid

Replacing
Spilled Acid

Kind of Water
to Use

Amount of
Water to Use

When to
Replace
Evaporation

Good Method
of Replacing
Evaporation

During discharge the gravity of the electrolyte becomes lower on account of a portion of the acid in the electrolyte being combined in the plates in producing the current. Thus, at the finish of a normal discharge the electrolyte is 100 to 150 points lower than at the beginning. When the battery is recharged, the acid will be returned to the electrolyte and will restore it to the former gravity.

Adjusting the Specific Gravity of the Electrolyte

The electrolyte of a fully charged cell of the vehicle type should, when first put into service, have a specific gravity of 1.270 to 1.280; but although with age this gravity will change somewhat, the battery will continue to give good service between the limits of 1.250 and 1.300. If the gravity should ever rise above 1.300, it should be promptly lowered by replacing some of the electrolyte with water. Low gravity in a battery or cell is usually caused by acid being combined in the plates through lack of charge, although if a battery is upset and acid spilled or if a jar is broken and acid leaks out, no amount of charging will restore the specific gravity. In the event of any cells having been flooded, by wash water or other causes, provision should immediately be made to prevent a recurrence. Decreasing gravity throughout the battery (*when not due to insufficient charging*) indicates that sediment is accumulating in the bottom of the jars.

Gravity
too High

Gravity
too Low

Before attempting to *raise* the gravity of any cell by adding acid, always charge the battery until *sure* that a maximum gravity has been reached; or in other words, that no acid remains combined in the plates. For example, if the electrolyte in a cell should be adjusted to 1.275 when 50 points of acid remained in the plates, the gravity would come up to 1.325 if the cell were afterward charged to its maximum.

Charge to
Maximum
before
Adjusting

To adjust the specific gravity to its proper value (1.270 to 1.280), first bring the battery to its true maximum, which can only be assured by charging until there is no further rise in gravity during a period of at least twenty-four hours of continuous charging at about one-half the normal "finishing" rate. Remove the electrolyte down to the top of the plates and replace with water or 1.300 electrolyte as required.

How to Adjust

When much adjustment is necessary and facilities are available, as in garages or large installations, it is good practice to pour the electrolyte out of the cells into a glazed earthenware vessel or lead lined tank, and raise or lower the gravity of this electrolyte as may be necessary. About one-third of the electrolyte is held in the plates and separators and cannot

be poured out, and this should be allowed for in estimating the proper gravity before refilling the cells.

In cases where there was a wide variation between different cells, further adjustment may be necessary.

Never
Add Acid

Unless acid is actually known to be lost out of a cell, none should ever be added during the entire life of a battery. The amount of acid lost in spray is immeasurably small and should be neglected.

Shipping Water and Electrolyte

Sulphuric acid, when shipped by freight, is classified as dangerous and therefore must be marked with a label as shown in Fig. 1.



Fig. 1. White Label for Freight Shipments of Acids. (Reduced Size)

These labels must be supplied by the shipper, although they may be obtained from local freight agents. On the bill of lading for all acid shipments, make the following notation:

"This is to certify that the above articles are properly described by name, and are packed and marked, and are in proper condition for transportation, according to the regulations prescribed by the Interstate Commerce Commission."

The following is a copy of the requirements of the Interstate Commerce Commission in this connection:

"The American Railway Association
REGULATIONS
for the
TRANSPORTATION OF INFLAMMABLE ARTICLES
AND ACIDS

Approved May 19, 1909; amended May 18, 1910

GENERAL NOTICE

Shippers' certificates and labels are prescribed herein, to facilitate compliance with Section 235 of an Act of Congress, approved March 4, 1909, which required shippers of explosives and other dangerous articles to plainly mark the contents of each package and to inform the carrier of the true character thereof, and also to comply with the requirements of the Interstate Commerce Commission's Regulations for the Transportation of Explosives.

Section 1853. Sulphuric or Hydrochloric Acids and Liquid Chlorides must be packed in earthen jars or glass bottles, or strong carboy bottles, without local defects, all well stoppered to prevent leakage, or in drums or tank cars. Jars or bottles must be packed in a strong case and well cushioned; carboy bottles must be packed in cases provided with strong handles or cleats, and the necks of carboys must be protected."

Acid will be accepted by the freight companies in glazed earthenware jugs, suitably packed, or in the regular carboys. When shipped in carboys, the neck of the carboy must be protected.

Distilled water may be shipped by freight in any kind of vessel; but in order to distinguish it from acid, it should be marked as distilled water, which will enable it to be shipped with less difficulty.

As distilled water is usually obtainable locally, there is seldom an occasion to ship it by freight.

When sending by express samples of electrolyte for analysis, send at least one pint, and in order to comply with the Interstate Commerce regulations, this must be packed in

bottles of strong glass or earthenware jugs of not to exceed 5 gallons capacity and stoppered with ground glass or rubber stoppers, packed in strong wooden boxes cushioned with absorbent packing material in quantity sufficient to absorb and hold all of the liquid.

On the outside of the package put the regulation caution label, which is a square white label as shown in Fig. 2.

As it is so often desired to obtain analysis of acid and water for use in connection with storage batteries, this Company has arranged to analyze, free of charge, any samples sent prepaid to us by customers for that purpose. For analysis of water, at least a quart is required; for acid, a pint is sufficient. Put a label on each bottle showing its contents and where it is from. Send the sample by express, prepaid, to The Electric Storage Battery Company, 19th Street and Allegheny Avenue, Philadelphia, Pa., and write a letter advising of the shipment and to whom the report of the analysis should be sent.

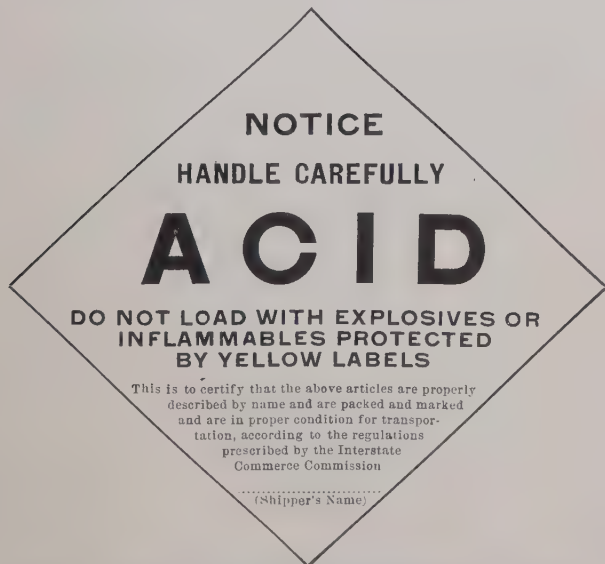
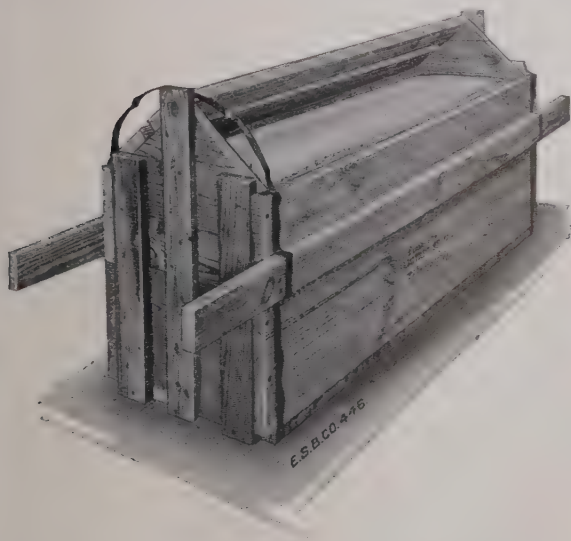


Fig. 2. White Label for Express Shipments of Acids and Corrosive Liquids. (Reduced Size)

How to Pack for Shipment

The damage in transit to batteries returned for repairs has shown the necessity of using care in packing, and the following procedure is therefore recommended:

1. Procure a strong box (see illustration) of 1 inch to 1½ inch lumber and made with A shaped ends to prevent the package from being placed upside down. The inside dimensions should be at least 2 inches greater than the overall size of the trays to be packed, allowing in addition 2 inches



Box

between trays when more than one is to go in the box. If the trays are not too large, two, or even more, may be packed together, but if possible a weight of 200 pounds per package should not be exceeded.

2. Cover the bottom of the box with a layer of excelsior, shavings or coarse sawdust at least 2 inches thick, and on this place each tray of cells. Over the top of the cells place

Packing

paraffined paper, and then cover the whole tray with stout wrapping paper, folding it down over the sides of each tray to keep packing material and dust out of the cells.

3. Fill the space around the sides and ends of trays with excelsior, coarse sawdust, shavings or even twisted and crumpled balls of paper, ramming down tightly.

4. Leave the tops of the trays free of packing material and covered only with the paper.

5. Nail slats on the box for a cover—never make a solid cover—and nail a stout strip on each side, extending beyond the ends, for handles. The slatted cover enables the freight handlers to see the contents of the package and helps toward careful handling.

Labeling 6. Label the box "Handle with Care" and "Do Not Drop."

General Suggestions

Shipping Instructions Before making shipment, always write to the nearest Sales Office of the Company for shipping instructions.

Marking Packages Number the packages and always mark each packing case clearly with the name and address as given in the shipping instructions. *Do not address to Sales Office.* Also mark with your own name as shipper, for identification upon arrival at destination.

When sending bill of lading to the nearest Sales Office, advise them of the entire contents of each package.

Bills of Lading All freight is handled most expeditiously and carried at least expense when bills of lading are made out correctly, and shipment described according to the terms of the railroad freight classifications.

Completely assembled batteries should be shipped as "Electric Batteries, N. O. S."

Note.—No railroad caution labels are required; the electrolyte is so dilute that it is specifically excepted from the label rules when contained in the cells of a battery.

Miscellaneous Shipments Boxes of good elements or plates should be shipped as "Lead Battery Plates."

Boxes of worn-out plates should be shipped as "Scrap Lead."

HOW TO PACK FOR SHIPMENT

Boxes of jars should be shipped as "Rubber Battery Jars"; covers and rubber separators as "Rubber Goods."

Empty trays should be shipped as "Empty Wood Crates."

The foregoing briefly covers the principal features of careful packing, and failure to observe these suggestions or good substitutes for them almost invariably entails heavy loss and damage in transit. Claims against the carrier in such instances can rarely be successfully pressed to settlement because the carrier can readily establish the fact that the damage is due to improper packing.

Caution

George Bailey Export Bureau
325 North 4th Street
West Philadelphia, Pa.

Lead Burning

The joints between plate lugs and straps and the cell to cell connections in vehicle batteries are usually made by melting the parts to be joined and forming an integral weld. The process is called "lead burning," and is carried out either with a hydrogen flame or with an arc burning outfit. The hydrogen flame makes a quicker and neater job and is, therefore, generally used where burning is done on any considerable scale.

In all lead burning, absolutely clean surfaces are essential to good workmanship. Lead is soft and very readily cleaned with a scraper or file. In the case of a battery which has had electrolyte in it, the surfaces to be burned should first be wiped over with ammonia or soda solution, applied with a piece of waste, and then allowed to dry before scraping. The acid is thus neutralized and removed.

Cleaning
Surfaces

BURNING WITH THE HYDROGEN FLAME

In assembling plates into groups, the top of the plate lug should be melted until it welds with the sides of the strap hole, and extra lead, melted and run off from a piece of "burning strip," then introduced to fill the joint flush. In case the joint appears to be getting so hot that there is danger of lead running away, burning should be started on another plate, so as to give the first one a chance to cool off before finishing.

Assembling
Groups

In burning connectors on pillar straps, the connector should be tapped into position so as to be a tight fit on the post before burning is started. Should the post project into the connector too far, it should be trimmed off, since the weld should be about $\frac{1}{8}$ inch deep. The top of the post should be melted first and then fused to the walls of the connector hole; after that, lead from a piece of burning strip can be run in until the joint is flush.

Burning on
Connectors

In the case of butt joints, as between the ends of strap connectors, from $\frac{1}{8}$ to $\frac{1}{4}$ inch space should be left between the points to be joined, so that the joint will go all the way through. Additional lead should not be introduced until the two ends are melted through to the bottom. Some sort of

Butt Joints

platform which brings the top of the generator to the waist line. If burned by vitriol, apply oil, not water.

In running the hose from "K" to "N," so arrange it that there will be no low points for water of condensation to collect, or, in other words, this hose should drain back at every point into the water bottle. If, however, water should collect in the hose to such an extent as to interfere with the flame and it cannot be readily drained off, proceed as follows: Kink the hose between "T" and "U" and detach it from "K"; close the stop cock at "W" and pump until a strong pressure is obtained in the tank; then close the stop cock at "V," opening those at "S" and "N," and finally quickly open at "W"; the pressure in the air tank will then force the water out of the hose.

The length of the hose from "T" to "U" should not be excessive, as the mixing cocks at "S" and "N" should always be within reach of the man who is handling the flame.

To prepare the flame for burning, close the air cock at "S" and open wide that at "N," hold a lighted match or candle to the gas until it burns, then add air and adjust the gas cock slowly, turning toward the closed position, until the flame when tried on a piece of lead melts the metal and leaves a clean surface.

The burning tip to be used depends upon the nature of work to be done; in practically all vehicle battery work the tip with a medium hole is suitable.

Replenish the zinc every few days, keeping it up to the prescribed amount.

When a charge is exhausted or the generator is to be laid up for the night, the old solution should be drawn off before making up a new charge, and the generator thoroughly washed out by flushing with water poured into the upper reservoir "A." If laid up for the night, the new charge should not be put in until the generator is used again. To empty a generator, first pull off the hose at the nipple "K"; then the hose at the nipple "E," and finally the rubber plug at "H." Care should be taken not to allow the solution to splash on anything and not to dump it where it will damage cement, asphalt or wood flooring or walks. If run into a drain

it should be thoroughly flushed with water immediately afterwards.

If solution is spilled where not intended, its action can be stopped by using baking soda, washing soda or ammonia.

BURNING WITH THE ARC BURNING OUTFIT

The advantage of the so-called "arc" burning lies in its convenience, since the battery being worked upon is used as a source of current for the operation, rendering further accessory apparatus unnecessary. This outfit, as supplied by The Electric Storage Battery Company consists of the following parts: Carbon holder with cable, clamp and $\frac{1}{4}$ inch carbon rods. Parts

Although called the "Arc" Burning Outfit, more satisfactory results can be obtained by using the heated carbon like a soldering iron, without actually drawing an arc.

As stated above, the battery to be burned is usually used as the source of current. From two to four cells are required, the former when the battery is fully charged, the latter when it is pretty well discharged. If it is completely discharged, an outside source must be used, and for this purpose a six volt "sparking" set is suitable, one terminal being connected to the connection to be burned, the other to the cable of the burning tool. The number of cells chosen should be sufficient to heat the carbon to at least a bright cherry red while it is in contact with the joint. A little experience will soon demonstrate a satisfactory degree of heat. The cable is connected by means of the clamp to a cell in the battery the required number of cells away from the joint to be burned, and either positive or negative to it. Care should be taken that good contact is made by the clamp, the lead being scraped thoroughly clean before the connection is made. The carbon should be sharpened to a long point like a lead pencil and should project not more than 3 inches from the holder. The latter should be cooled off occasionally by plunging it, carbon and all, into a pail of water. After being used for a short time, it will be found that the carbon will not heat properly, due to a film of scale formed on the surface.

MANUAL OF "Exide" BATTERIES IN ELECTRIC VEHICLES

This should be cleaned off with a knife or file, as occasion requires.

As in the case of hydrogen flame burning, additional lead to make a flush joint should not be added until the metal of the pieces to be joined has melted. The carbon should be moved around to insure a solid joint at all points.

When burning pillar strap connections, the process is rendered easier and the results more satisfactory if a little dampened asbestos or clay be moulded around the outside of the connector.

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